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DO INSTRUCTIONAL METHODS USED IN THE MANUFACTURING PROCESSES LABORATORIES CONTRIBUTE TO TRADE TRAINING OR TO ENGINEERING EDUCATION?*

By R. L. SWEIGERT

Georgia School of Technology

This paper is presented for the purpose of provoking discussion. It is hoped that those present at the meeting at Pennsylvania State College will contribute their opinions and experiences. It is also hoped that the outcome of this meeting will point rather definitely towards the instructional policy that should be adopted in improving the manufacturing processes laboratories.

The writer has purposely used the term manufacturing processes laboratories to the exclusion of the term shops. It has been stated in the past that regardless of the name we may apply to these laboratories they still remain shops. I believe in many cases that may be true. However, the committee on manufacturing processes laboratories, of which I have been a member since its inception in 1934, advisedly selected the name manufacturing processes laboratories as a name emphasizing a new type of laboratory which should contribute to engineering education, rather than to trade training.

I believe it is necessary to set up objectives before we can attempt to travel a certain path. The path we travel depends upon those objectives, not only in their statement, but also in their actual application. I have seen quite a number of cases where fine objectives have been stated and those in a position to carry out those objectives have gone blithely on their way, ignoring the final goal. In the development of the manufacturing processes laboratories it is not only necessary to set up sound objectives, but it is also necessary that these objectives be followed if we expect to gain the stage of development that is possible. I believe it in order to restate the objectives for manufacturing processes laboratories. The objectives are not new. They have been thrashed over and were apparently agreed upon at the Cornell meeting in 1934. From that time to

* This paper is written to form the point of departure for a round-table meeting of the Mechanical Engineering Division to be held Wednesday afternoon, June 21, at the 47th Annual Meeting, S. P. E. E., at The Pennsylvania State College.

this, in so far as can be judged by published information, there has seemed to be comparatively little application of these objectives. Undoubtedly some schools have done more than others. Some may have done fine things which have not been publicized. I am hoping that the open discussion in June will bring out such work.

A study,* made on a nation-wide basis by the writer, the results of which were published in the JOURNAL in 1931, produced the following objectives for manufacturing processes laboratories. Placed in the order of their importance as indicated by the study, these are:

1. To give a knowledge of materials.
2. To give a knowledge of design.
3. To illustrate fundamental principles of engineering.
4. To give a knowledge of production and manufacturing.

Professor Boston of Michigan gives the following objectives from a study he made: "The general purpose of shop courses is, then, to acquaint the student first-hand with materials, the technique of working them, and the economic phases of production."

Professor Casberg of the University of Illinois restated the objectives † in 1934: ". . . the aims and purposes of a machine production laboratory course are to give the engineering student a knowledge of the economic phases of machine production together with the technical knowledge of materials, tools, machines, and processes."

It is evident that there seems to be very good agreement. There is no material difference in the above statements of objectives.

If there are any who disagree with the above objectives, it is hoped that such disagreement will be brought out at Pennsylvania State College and that we can leave that meeting with the objectives firmly established.

The final part of this discussion takes up the instructional methods to be used in reaching the objectives which have been mentioned. It does no good whatever to establish fine objectives unless those objectives are made effective in the instructional methods used.

Based upon the stated objectives, if the instructional methods were developed to carry out these aims, the engineering student should know the relation between the properties of materials and their processing. If he knows how different materials may be processed, if he knows how these materials affect the selection of

* "A Study of Some of the Phases of Shopwork As a Part of Professional Engineering," JOURNAL OF ENGINEERING EDUCATION, June, 1931, pages 657–687.

† "Laboratory Procedure In Teaching Machine Production," JOURNAL OF ENGINEERING EDUCATION, February, 1935, pages 419–425.

machines, tools, and feeds and speeds, if he knows the relationship of various heat treatments to the material properties, and machines, tools, time and power required, he will have obtained an education in the processing laboratories that, I believe, can be classified as of engineering caliber and such a course should be as valuable as any other course in the curriculum.

If the above is accepted as desirable—and it is if the established objectives are accepted—then, any instructional methods adopted should produce such education.

It is apparent that there is nothing stated that involves trade training. While some changes have been made in the processing laboratories, there still seems to be too much time devoted to doing things which contribute more to trade training than to engineering education.

I see no reason why the processing laboratories should vary fundamentally in their instructional methods from the methods used in other mechanical engineering laboratories. I, therefore, present that method as a method to be adapted to the processing laboratories. It seems to me that the body of material involved in the processing laboratories could be advantageously divided into a group of experiments which would cover the material. Along with these experiments would be included necessary lectures or class periods, texts, notes, demonstrations, problems, and so forth.

To illustrate the type of experiments involved, the following might be mentioned. In any given processing situation there are a number of variables affecting the situation just as there are in the case of an internal combustion engine or steam turbine problem.

Certain variables may be held constant and the effect of the variation of another variable may be studied. For example, the material, tool and machine, may be set and the best relationship of feed and speed determined for that particular material. The power required could also be checked at the same time. Comparative tests could be made as between a shaper and a milling machine for certain classes of work.

One of the prime purposes of the experimental topic would be to focus the attention of the student upon the factors affecting the situation.

I feel that some such method would present the material in such a way that it would be much more valuable in such courses as machine design and in industrial engineering. In general, at present, I believe it can be stated that the carry over is very small; also, that the carry over into industry, except possibly the nomenclature, is small.

The purpose of presenting the above objectives and suggested instructional method in regard to presenting the material in the

manufacturing processes laboratories is to initiate the discussion for one of the sessions at the June meeting of the Mechanical Engineering Division.

Some institutions have already done some work along the lines suggested here. It is hoped that many of those who have tried new methods will contribute information on those new methods and their results. It is hoped that those who have not recently tried something new will contribute their thoughts and reactions to the suggested laboratory method and also contribute their point of view, at the meeting, on the various methods and instructional aids that are being tried.

The following information pertaining to the MINNESOTA SECTION was omitted from the year book:

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1939 Meeting, May, University of Minnesota.

INDUSTRY EVALUATES THE INDUSTRIAL ENGINEERING CURRICULUM

By GEORGE A. MANEY and ARTHUR B. BRONWELL

School of Engineering, Northwestern University

The status which should be accorded industrial engineering education in our engineering schools is a subject which has received considerable attention in recent years. The growing interest in this field of education is evidenced by the adoption of a separate curriculum in industrial engineering by a number of engineering universities. Because this step represents a departure from the more basic engineering training, it is deserving of careful consideration. While there has been much controversy on this issue and numerous articles have been published on the subject, so far as is known, there has been no previous attempt to obtain a large scale expression of industrial opinion as to the justification for a separate curriculum for teaching industrial engineering. Since, in the final analysis, all engineering graduates enter industrial pursuits, it was thought that the experience of industry with its engineering graduates would provide a valuable guide in determining whether or not an industrial engineering curriculum is justified. Accordingly, a survey was conducted at Northwestern University to invite leading industrial men in the fields of administration, personnel, and engineering to express their views on the desirability of a separate and distinct curriculum for teaching industrial engineering as contrasted with the industrial option type of normal engineering curriculum. Information was also requested which will assist in gauging the demand for industrial engineering graduates.

Over 300 questionnaires were mailed to a select list of leading executives in telephone and electric utilities, oil companies, steel companies, railroad and air transportation industries, a wide variety of manufacturing companies, and other miscellaneous industries. Since the manufacturing and steel groups are chiefly interested in industrial engineering education, the largest number of questionnaires were directed to these industries.

The letter of transmittal contained comparisons of the subject matter presented in typical curricula in (*a*) the straight engineering curriculum with a business option, (*b*) the industrial engineer-

ing curriculum, and (*c*) the business administration curriculum as offered in commerce schools.

Analysis of the Replies Received

The 122 reporting companies employ over 2,500 engineering graduates annually. Of these, 56 expressed a preference for a separate industrial engineering curriculum, and 55 preferred to incorporate industrial engineering training into one or all of the existing engineering curricula. These over-all figures are, however, somewhat deceiving, as they are easily influenced by the number of replies received from the different types of industries. Table I gives

TABLE I

Type of Industrial Group	No. of Reporting Companies	Average No. of Engineering Graduates Employed Annually *	No. Favoring I.E. as a Separate Curriculum	No. Opposed to Separate I.E. Curriculum	No. not Expressing Definite Opinion	No. of I.E. Graduates They Prefer †	Per Cent of I.E. Graduates Preferred to Total Engineering Graduates
Manufacturing..	80	1,664	38	31	11	321	19.3
Steels.....	7	159	5	2	0	18	11.3
Utilities.....	9	513	3	6	0	20	3.9
Oils.....	9	113	1	8	0	0	0.
Rails.....	6	15	0	6	0	0	0.
Air Transport...	2	7	1	1	0	3	43.0
Miscellaneous...	9	65	8	1	0	65	100.0
	122	2,536*	56	55	11	427†	16.9

a more complete analysis of the results. From this table, it is seen that the majority of correspondents in the manufacturing, steel, and miscellaneous groups favored the separate curriculum. The utility, railroad, and oil industry correspondents favored the inclusion of industrial engineering subjects in the straight engineering curricula, or were opposed to this type of training altogether. Among the larger manufacturing and steel companies the opinions were about equally divided as shown by the fact that the companies favoring the separate curriculum employ 866 engineering graduates annually, while the opposing companies have an annual employment of about 896 graduates.

On the basis of the replies received, the potential market for engineers following an industrial engineering curriculum represents approximately 17 per cent of the total demand for all engi-

* Of the 122 reporting companies, 30 did not report the average number of engineering graduates employed annually and are therefore not included in this figure, although their opinions on Industrial Engineering are included.

† Twenty-two did not give figures. It was assumed that those opposed to the separate curriculum would not prefer industrial engineering graduates.

neering students. Here again, the percentages by component groups are a more reliable guide. Among the manufacturing and steel groups the percentages were 19 per cent and 11 per cent, respectively. Some correspondents expressed a preference for a relatively large percentage of industrial engineers as compared to those engineers following the "business option" engineering courses.

Details of Questionnaire

Typical curricula in all branches of engineering education were supplied to each correspondent. In addition, a summary of the subject matter and relative amounts of time devoted to the major fields of study in each curriculum were included. The following questions were asked of each correspondent:

"1. Approximately how many engineering graduates does your organization employ annually?

2. What percentage of these enter pursuits in which a combined business and engineering education would serve as a better preparation than specialized engineering training?

3. In your estimation do the normal engineering curricula with business option (curriculum *A*) in themselves satisfy this demand, or is there a sufficient need for engineers trained in industrial engineering as defined above to justify a separate and distinct curriculum? (Comparisons of the subject matter in the following curricula were supplied:

A. The normal engineering curriculum with industrial option.
B. The industrial engineering curriculum.
C. The business administration curriculum offered in commerce schools.)

4. Approximately what percentage of the engineers employed by your organization would you prefer to be trained in industrial engineering as outlined above?

5. Indicate by numbers (1, 2, 3, etc.) the order of preference of the fields of industrial study you believe to be most important in a course in industrial engineering?

———— Industrial Organization and Management
———— Factory Management and Production Control
———— Marketing and Sales Administration
———— Cost Accounting
———— General Accounting
———— Corporation Finance

6. What methods can you suggest to improve the teaching of industrial engineering?"

In response to this survey many correspondents dictated extensive letters giving their views on this subject. Since these comments represent the experience of industries employing well over 2,500 engineering graduates annually, they constitute a valuable market analysis upon which to build the industrial engineering program.

Discussion of Pros and Cons

The following principal arguments were advanced in favor of a separate curriculum in industrial engineering:

1. The growth of modern industry has developed a broad specialized field for engineers in problems of production control, determining and controlling manufacturing costs, factory layout work, and in the general organization and management of business. This demand should be met by specific education in these fields. A student receiving a fundamental training in mechanical engineering or any of the other basic engineering fields containing only a limited range of industrial subjects, and having the intention of later entering an industrial engineering career is following a detour route and does not receive the specific training which will be applicable to his future career.

2. A reasonably satisfactory four-year program of education has been worked out for engineers in the fields of civil, electrical, mechanical engineering, etc. This is evidenced by the large number of students who enter professions without having to pursue post-graduate studies. Is it not also possible to work out a satisfactory four-year program for industrial engineers which will give them specifically what they most need without the necessity of extensive post-graduate studies?

3. While industrial engineering courses are available to engineering graduates in the evenings in some of the larger cities, it is often difficult for the industrial engineer to pursue such courses because of the unfavorable location of the factory or plants, or because of unfavorable working conditions. Factories are often remotely located from educational centers, and in smaller cities where education along industrial lines is not available to the engineer, he is compelled to fall back on self-education and acquiring the necessary knowledge from experience.

4. A few of the large companies offer employee training courses. These are often of the nature of job training courses, and as such, are limited in scope to one particular method and seldom present the broader fundamentals of the subject. A large number of engineers are employed by small companies which cannot offer either the breadth of experience or the training program offered by the large

companies. Here the engineer is definitely on his own unless he is fortunate to be favorably situated near a large city where it is convenient to take night school work.

5. An increasingly large percentage of students are forced into lines of business in which they have little or no opportunity to apply their engineering training. New fields of business are demanding men trained in engineering and frequently offer better promotional possiblities than the crowded engineering fields. Several correspondents pointed out that the graduate who had combined a liberal selection of business and industrial subjects with the engineering training would be better qualified to adjust himself to such occupations than the engineer who had received only a cursory business training.

The following opposing arguments were presented:

1. An industrial engineering curriculum attempts to cover both engineering and business subjects. The student is required to divide his attentions and cannot, in four years, acquire enough engineering to prepare for an engineering career or enough business for a business career, and is therefore poorly trained in either field.

2. Engineering students who wish to supplement their engineering education with courses in business and management can enroll in evening schools for this type of work. Some large companies offer employee training courses designed to train the employee in their own business methods and procedures. It is less difficult for the student to fill in deficiencies in industrial training than deficiencies in engineering training.

3. The trend in engineering education is toward greater standardization along the lines of sound fundamental engineering education with less specialization. A separate industrial engineering curriculum is sometimes looked upon as a step away from this trend.

4. Engineers are sufficiently versatile to acquire the necessary knowledge of production methods and control, cost studies, motion study, and other industrial training without extensive formal education along these lines.

Specific Comments Favoring a Separate Curriculum

With regard to the advisability of offering a separate and distinct curriculum in industrial engineering, the following are a few of the typical comments received:

"There is, in my opinion, a sufficient need for industrial engineers *per se* to justify a separate curriculum. In our manufacturing and development organizations there are many problems of design, production control, and cost accounting that the other engi-

neers do not readily appreciate. . . . I do not believe that, with some 200,000 manufacturing companies in the United States, it should be difficult to justify a separate course in industrial engineering."

"Industrial engineering training would be very helpful all around, whether they decided to stay strictly in engineering work or branch out in other departments."

"My tentative conclusion is that two types of courses will eventually be necessary: first, a strictly engineering course with some provision for electives among industrial subjects, and second, an industrial engineering course where much more emphasis is placed on industrial subjects."

"We have noted that the industrial engineering training has been helpful in developing junior executives for positions involving production management, as apart from the straight engineering courses intended for the more technical kind of position, as, for example, research and development, or plant engineering."

Specific Comments Opposing a Separate Curriculum

"In the educational program of the company we are able to offer many industrial engineering subjects in addition to other technical material. Thus, we feel that the man trained in pure electrical or mechanical engineering, who proves to the company and to himself that he should follow industrial engineering, can without loss of time or any particular difficulty, accumulate the necessary industrial engineering subjects that will be useful to him in his later work."

"It is only possible to study engineering subjects satisfactorily as a regularly matriculated student. On the other hand, one is able to take extension, night school, or even correspondence courses in industrial and commercial subjects and thus acquire the essential information in these fields."

"It has been proved to us that it is an easy matter for an ambitious graduate, who desires to change his occupation to non-technical work, to select his related subjects and continue his education concurrently with the demands of his new occupation."

"It is very evident that the average four-year student cannot in this length of time get an adequate engineering education and at the same time learn anything about manufacturing processes, industrial organization and management, industrial relations and personnel, general accounting, cost accounting, corporation finance, business law, and budgets."

Recommendations for the Industrial Engineering Curriculum

In reply to the question on the relative importance of the various fields of industrial study, numerous correspondents pointed out that industrial engineering education should be aimed at a broad field of specialization. The chief realm of the industrial engineer is in the fields of production control, factory layout, cost reduction, manufacturing expense budgeting, valuation, and similar lines of endeavor. The industrial engineering curriculum should be directed toward an adequate preparation in these fields, rather than distributing the student's efforts over subjects which have only occasional application. Attention should be concentrated upon those subjects which will have the greatest application in the early career of the engineer, in place of the "cold storage" type of subject which finds application only in the later stages of the engineer's career. Such fields of study as corporation finance, banking, etc., were viewed by many as cold storage subjects. A few correspondents requested the inclusion of salesmanship.

A large number of correspondents stressed the necessity of maintaining a competent, experienced faculty who keep in constant contact with industry. Frequent plant visitations and case studies of actual industrial problems were urged as a practical method of teaching industrial subjects. Conferences with industrial executives were also encouraged.

Several correspondents expressed the belief that industrial and commercial courses do not satisfactorily teach the broad underlying philosophies of industry and its place in the economic society, the understanding of coöperative endeavor, and a proper understanding of the human components of industrial problems. Recommendations were made to broaden the courses in Industrial Organization, Humanities, and Industrial Relations to include more of these vital philosophies. The importance of training in personal adjustment to business and the cultivation of the spirit of coöperation in all engineering students, was repeatedly emphasized in the replies received. Of those correspondents who wrote specific comments on this subject, approximately 23 per cent stressed the importance of this type of training for all engineering students. It is felt that these unsolicited comments touch upon one of the most important fields of future development in engineering education. Several of the typical comments are given:

"Add to the curriculum courses in Public Speaking and Personality Adjustment. Ninety per cent of the failures in business are due not to the lack of adequate training or ability, but because of various personality defects. A large part of these defects can

be corrected or improved in college through the medium of such courses."

"Our people, and more especially our executives, feel that the greatest weakness in engineering graduates is the lack of personality."

"Much more emphasis on human engineering—how to get along with people."

"The extra-curricular activities should be encouraged in a college student to the point of developing self-assurance, pleasing personality, aggressiveness, and an understanding of how to get along with others. My personal observation has been that this second requirement is entirely neglected; in fact, in a great many colleges it is directly discouraged."

Criticisms of Industrial Engineering Curriculum

One objection to a separate curriculum in industrial engineering is the danger of such a curriculum becoming a catch-all for marginal students who have no other desire to take industrial engineering than to escape the more difficult technical subjects in lieu of the easier industrial courses; their selection of industrial engineering being merely to follow the path of least resistance toward an engineering degree. In addition to this group, there is another group which is undecided as to the particular field of engineering to enter, and which is inclined to select the industrial engineering curriculum as an easy compromise to the problem. This process of negative selection of the curriculum to pursue is detrimental to everyone involved. The student prepares for a field of endeavor which he may have no desire or intention of pursuing, and the industrial engineering classes may, as a result, contain a relatively large percentage of marginal students whose work will probably be inferior to the average. The problem of selection of students who are to take industrial engineering is probably more acute and requires greater supervision than in the straight engineering courses. Several correspondents recommended that industrial courses should be made just as difficult and as exacting as the engineering courses to avoid the impression among the students that industrial engineering is a snap curriculum. Higher standards in the teaching of industrial courses are often possible when these subjects are taught in a separate commerce school which is removed from the influences of the engineering school but closely coördinated with the engineering school.

Conclusions

In conclusion, the results of this survey appear to indicate a definite need for engineers with a training in fundamental engineering subjects, supplemented by extensive industrial studies such as can be offered only in a separate industrial engineering curriculum. The greatest demand for engineers with this type of training appears to be in the manufacturing, steel, and miscellaneous industries. The educational program for industrial engineering should provide specialized training along the lines of endeavor in which the industrial engineer is likely to become engaged, rather than a general over-all education. Although the industrial engineering graduate has certain deficiencies along specialized engineering lines, it is felt that the versatility of this type of graduate in fields of endeavor for which he has not been specifically trained, in most cases, is comparable to that of the graduate who specializes along the more basic engineering lines. The industrial engineering curriculum no doubt offers a better preparation for those graduates who enter business pursuits at the start of their career than the more basic engineering curricula. Since a fairly large percentage of engineering graduates fall into this category, there is some basis of justification for the industrial engineering curriculum here.

It is felt that the importance of training to develop in all engineering students an aggressive, coöperative spirit, and pleasing personality is a vital phase of education which has not received sufficient attention in the past and one which merits more serious consideration.

While this survey is not intended to constitute an accurate market analysis, it would appear that the demand for industrial engineers represents about 18 per cent of the total engineers employed by manufacturing companies, 11 per cent of those employed by steel companies, and a large percentage of those employed in miscellaneous business concerns. Because of the somewhat limited demand for industrial engineers, it is probably advisable that industrial engineering be offered only by engineering universities which are best equipped to teach industrial subjects, rather than becoming universally adopted, as such a procedure would probably saturate the field.

The authors wish to acknowledge gratefully the contributions of all the correspondents participating in this investigation and their many helpful comments on this subject.

EVALUATION OF FACULTY LOADS IN INSTITUTIONS OF HIGHER LEARNING

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The Problem

No issue is more moot among college faculties today than the question of what constitutes a proper load for the teacher. If one were to ask the opinions of the members of any faculty on the amount and kind of service that should be required of them, there would be nearly as many different replies as persons comprising the faculty. A cross section of honest opinions would reveal many who feel that their talents and time are either misdirected or abused; others who feel that valuable time is wasted in performing routine tasks, and still others who feel that much of the work required of them might well be done by assistants or dispensed with altogether. Moreover, there would be few who could not point to what they believe to be inequalities in the loads carried by themselves in comparison with those of colleagues. The following situation is typical:

A university appoints an instructor in English and another in Mathematics. Each is to carry a weekly load of fifteen hours consisting of several sections of one course. What appear on paper to be comparable teaching assignments may work out in actuality somewhat as follows:

English Instructor—five sections at 25 students per section, each meeting three times a week, involving correction of a weekly theme and quiz from each of 125 students.

Mathematics Instructor—three sections at 25 students per section, each meeting five times a week, requiring correction of daily home work and weekly quiz from each of 75 students.

The English instructor is literally snowed under with theme correction work, conferences, and written quizzes, while the mathematics instructor can complete his correction work in considerably less time and with much less effort. This is only one illustration of the type of maladjustment in loads that may arise. Such situations exist at all levels and in all branches of higher education, and not only do they cause misunderstandings and give rise to

grievances, but also they lead to mental attitudes that destroy individual initiative, loyalty, and effectiveness.

Equally aware of and no less disturbed about this matter is the administrator in charge of assigning the faculty loads. His role is far from easy; he must see that the work of the institution is accomplished as well as possible, while at the same time he is conscious that his assignments are not entirely satisfactory from either the institutional or individual viewpoint. Only too well does he know that his own judgment must be his principal guide and that he does not have adequate measures with which to gage the quality and quantity of various assignments.

In the past, attempts have been made to get at this problem by having groups of faculty members keep records of the distribution of their time for a specified period. From such reports figures have been compiled showing the average time devoted to various aspects of academic work, such as preparation for lectures, recitations, and laboratory work; the correction of papers; administrative duties; research, etc. Such surveys have thrown some light upon the subject, but they are in general open to the following objections:

(1) In reporting these data, teachers are likely to exaggerate the time spent in various activities. This is only natural since the instructors realize they are to be judged and their loads directly affected by the results.

(2) Even assuming the teachers' reports to be strictly accurate, the period during which such a time analysis can be kept by faculty members—one or two weeks—is not sufficient to take into account the variety of tasks a teacher is called upon to do. Hence the reports may not give a true picture of the real distribution of his time throughout a term.

(3) The results obtained have been related to general types of work, such as lectures, recitations, etc. rather than to specific courses. This would imply that a lecture in any subject involves the same load upon the teacher as a lecture in any other subject—a questionable assumption.

(4) A summary of how teachers actually spend their time fails to discover whether the amount spent in any specific course is too much or too little for the achievement of the objectives of that course.

With these points in mind, the authors have approached the problem from a different angle, using modifications of certain techniques that have proved serviceable in industrial personnel work. For in many respects, a post on the faculty of any college or university is not unlike a job in industry. It entails a certain knowl-

edge, background, training, skills, etc., on the basis of which the faculty member is given certain tasks to perform—teaching, research, consulting with students, correction work, etc.

Ordinarily it is not possible for each faculty member to run his own show; his job is only one part of the whole and his contribution—valuable as it may be—must be coördinated and balanced with that of others to make the entire program more effective. This means not only the planning of a school program, but the wise administration of the time and effort of those who carry it on—the faculty. In short, higher education is a business—one in which the administrator is charged with the intelligent direction and use of the nation's most valuable resource—its learned men. How important, therefore, that their time and effort should be directed in the channels that will be of most value to their institutions and through them to society. Just as industry has had to evaluate its jobs to find out what is required for their effective accomplishment, so should the educational administrator apply similar measuring techniques to find out what academic assignments require of teachers.

As long ago as 1919 Leonard Koos, in a pioneering study of teaching loads in colleges and universities, deplored the fact* "that tradition, sentiment, rule of thumb, temporizing compromise have been, and unfortunately, still are, the dominant methods in this important field of human enterprise."

In the score of years that have since elapsed, there has been considerable discussion but only limited progress toward the solution of this vexing question. Many excellent statements have been offered, however, revealing the large number of factors that may enter into the determination of a faculty member's load, whether he be in teaching, administrative work, or both. Among the more important of these are the following:

(1) the number of different courses for which he is responsible,
(2) the nature and degree of difficulty of these courses,
(3) the number and the characteristics of students enrolled in each course,
(4) the amount of time for personal conferences with students outside of class,
(5) the extent of clerical or correction assistance provided,
(6) the time required for reading papers and examinations,
(7) the extra curricula student activities with which he is concerned,
(8) the amount of administrative work expected of him,

* "The Adjustment of the Teaching Load in a University," L. V. Koos, U. S. Office of Education Bulletin, No. 5, 1919.

(9) the extent of his professional society interests and obligations, and
(10) the research efforts demanded of him.

But most of these load components are very difficult to measure quantitatively; *i.e.*, in terms of the time and effort required for their successful performance. Except for the actual time spent in class each week by an instructor, the number of different courses he carries, and the number of students involved, very little accurate information is usually available upon which to base a precise computation of faculty loads. Perhaps for this reason, it is customary to speak of teaching loads in terms of semester hours, or "comparable teaching hours,"* even though this is obviously only a partial measure of what a teacher is actually doing.

Some educators have used the term *service load*, as distinct from *teaching load*, the former representing all the different assignments carried on by a teacher for the institution he serves. A computation of service load would need to include advisory, administrative, and research responsibilities as well as teaching. Since the courses taught by faculty members are the core of an institution's program, however, it would seem that the first step in the direction of an improved administration of faculty service loads is a more accurate measuring stick with which to determine the demands made upon teachers by the courses assigned to them. A technique for developing such a measure is found in what the authors have chosen to call Course Evaluation—the analysis of a course to determine what its successful conduct requires of a teacher.

Course Evaluation

There can be little agreement in the appraisal of anything without definition, so that the first requisite of course evaluation is a careful definition of the course itself; *i.e.*, there must be a careful statement with respect to the course under consideration of each of the following:

(1) The objectives or aims of the course.
(2) The materials of instruction used in the conduct of the course (the use made of text and reference books, and other printed materials; special equipment, instruments, etc., that are

* In computing "comparable teaching hours" an effort is made to allow for differences in teaching load occasioned by the use of lecture, recitation, or laboratory methods of instruction. Such computations are based on some arbitrary plan such as that one hour of lecture load is equivalent to one and one half hours of recitation classes, or three hours of laboratory work, the assumption usually being that all courses in all departments should be treated alike.

needed for effective instruction in the subject matter of the course).

(3) The method of conducting the course (size of the class; number of meetings per week; sections, if any; length of class period; requirements with respect to the amount and frequency of homework assignments, reports, quizzes, exams, etc.; where the latter are handled by assistants, this should be specified).

(4) The content of the course listed in detail in its chronological order of presentation.

When these factors are known, it is possible to specify the minimum requirements that will be demanded of whoever teaches this course. This is not to say that all instructors will be equally effective or that any two of them will handle the course in exactly the same way, but merely that the load imposed by a given course may be divided into (1) components due to the nature of the course itself and (2) components due to the degree of effectiveness with which a particular instructor teaches it. Course evaluation is concerned solely with the former and hence has no bearing upon the rating of individual instructors since it is an instrument designed to measure *minimum course requirements* and not the *performance* of *members* of the *instructing staff*. The latter is certainly important and should be taken into account in the administration of faculty loads, but the appraisal of the personal qualities of the teacher is a separate aspect of the problem and one which would only complicate and confuse the issue if it were discussed here.

These minimum requirements with respect to any course may be divided into three parts: (*A*) the minimum qualifications needed by any teacher who is to handle the course effectively; (*B*) the time per week required of the teacher; and (*C*) special considerations. It should be noted that these minimum teacher requirements arise from the nature of the course itself, regardless of who may happen to be teaching it at any given time.

The Minimum Requirements

Imposed on a Teacher by a Specified Course

A. Personal

1. Educational Background and Training

(*a*) Academic Training

General—Degrees, field of concentration
Desirable related fields of study

Special—Special study, such as training programs carried on by industry.

(*b*) Other Training—Training in shop, drafting room, etc.

2. Personality
   (*a*) Capacity to discipline (Does the course itself require less or more than ordinary disciplinary ability, poise, etc.?).
   (*b*) Capacity to motivate (Does the course itself require less or more than ordinary ability to stimulate interest and achievement in it?).
3. Experience
   (*a*) Teaching—One year, two years, etc.
   Experience in handling large or small classes; administrative experience required.
   (*b*) Professional and Industrial
   Experience as practitioner, consultant, employee or executive in industry. For example: Industrial experience may be very helpful in teaching courses such as Motion and Time Study, Machine Drawing.
4. Special Skills (*e.g.*, aptitude for research, etc.).

B. Time Per Week Required for the Teacher (The minimum hours demanded by the course *exclusive* of those in the classroom which should be indicated in the definition).

	Person Giving Course for First Time	Person Who Has Given Course No. of Yrs.
1. Preparation of Course Material Lectures; Demonstrations; Notes, Problems, Cases, etc.; Quizzes, Examinations.		
2. Correction (Homework, quizzes, examinations).		
3. Conferences with Students.		
4. Consultation with Staff (pertaining to conduct of this particular course).		
5. Bookkeeping; *i.e.*, making up grades, records, office reports, etc.		

C. Special Considerations (any requirements not covered under the foregoing headings):

To view a course objectively and determine what its successful conduct requires of its teacher is not an easy task. Not only does it

SUMMARY OF EXPERT OPINIONS ON MINIMUM REQUIREMENTS FOR TEACHERS OF SELECTED COLLEGE COURSES

Course	Degrees Required				Other Necessary Training			Required Years Experience	
Space Does Not Permit Inclusion of Course Definitions. Only Operating Plans are Indicated Here.	Number of Usable Replies	Figures Show Number of Replies Indicating Each Degree as Necessary			Fields Listed are Those Included in a Considerable Number of Replies			Figures Show No. of Replies Indicating Each	
		Bachelor	Master	Doctor	Professional	Related Fields	Cultural	Special	Prof.	Teaching
Analytic Geometry One section—30 engineering freshmen, five 50 minute periods a week	21	9	12	0	0	Physics Chemistry Engineering	English Effective Spkg.	Training in freehand sketching. Training in Pedagogy	None, 16 One, 4 Two, 1 Three, 0	None, 6 One, 6 Two, 7 Three, 2
Freshman Chemistry Lectures One lecture section—75 engineering freshmen, two 50 minute periods a week	20	1	8	11	0	Physics Math.	English Economics History	Effective Speaking	None, 17 One, 2 Two, 1 Three, 0	None, 7 One, 4 Two, 5 Three, 4
Freshman Chemistry Lab. and Quizz Three sections—25 engineering freshmen—one 50 minute quizz, and one 3 hour lab. period a week	20	10	9	1	0	Physics Math.		Skill in manipulative technics of the chemistry laboratory	None, 20 One, 0 Two, 0 Three, 0	None, 12 One, 5 Two, 2 Three, 1
Economics Two 50 minute lectures to 120 engineering students; 5 sections of 24 students each, for one 50 minute quizz period	22	3	11	8	0	Math. Statistics Sociology	English Effective Spkg.	Skill in graphical presentation. Training in economic research	None, 8 One, 7 Two, 5 Three, 2	None, 1 One, 5 Two, 6 Three, 10
Electrical Machinery 60 mechanical engineering students, four 50 minute lectures and one 2 hour preliminary report period all together. 3 sections for one 2 hour lab. period each week	21	20	1	0	0	Math. Physics Engineering		Training in applications of electrical machinery to industrial processes	None, 5 One, 7 Two, 4 Three, 5	None, 5 One, 3 Two, 6 Three, 6

FIG. I

tions for one 2 hour lab. period each week

FIG. I

SUMMARY OF EXPERT OPINIONS ON MINIMUM REQUIREMENTS FOR TEACHERS OF SELECTED COLLEGE COURSES—*Continued*

Course	Degrees Required					Other Necessary Training			Required Years Experience	
Space Does Not Permit Inclusion of Course Definitions. Only Operating Plans are Indicated Here.	Number of Usable Replies	Figures Show Number of Replies Indicating Each Degree as Necessary				Fields Listed are Those Included in a Considerable Number of Replies			Figures Show No. of Replies Indicating Each	
		Bachelor	Master	Doctor	Professional	Related Fields	Cultural	Special	Prof.	Teaching
Freshman English One section—30 engineering freshmen, three 50 minute periods a week	25	10	15	0	0	Literature English Grammar Foreign language	History Physical Sciences Social Sciences	Ability in Creative writing, criticism, and editorial work. Library technic	None, 20 One, 3 Two, 2 Three, 0	None, 16 One, 4 Two, 4 Three, 1
Heat and Air Conditioning One section—30 fourth year mechanical engineering students, three 50 minute periods a week	22	20	2	0	0	Steam Laboratory Building Construction		Steam fitting. Sheet metal work	None, 6 One, 7 Two, 6 Three, 3	None, 6 One, 4 Two, 7 Three, 5
Industrial Accounting 15 fourth year industrial engineering students. One 50 minute period; two 2 hour periods a week	19	9	10	0	2 (C.P.A.)	Cost Acctg. Economics Law Finance	English Social Sciences	Close contact with current trends in practice is necessary	None, 4 One, 6 Two, 5 Three, 4	None, 0 One, 9 Two, 6 Three, 4
Graphics 1 One section—30 engineering freshmen, two 3 hour periods a week	25	22	3	0	0	Shop work Production Processes	English Effective Spkg.	Skill in model making. Skill in drafting. Ability to visualize in three dimensions	None, 4 One, 11 Two, 6 Three, 4	None, 10 One, 7 Two, 2 Three, 6
Strength of Materials 60 engineering students for three 50 minute lectures; three sections for one 50 minute quizz period each week	33	18	15	0	0	Applied Mechanics Testing Mat. Lab.		Research ability. Engineering experience more important than graduate study	None, 12 One, 13 Two, 3 Three, 5	None, 11 One, 8 Two, 7 Three, 7

FIG. I

involve considerable time and effort, but also it requires that the appraiser keep his mind free of personal considerations and think only in terms of the particular course which has been defined for evaluation.

The data sought as a means of determining these minimum requirements are best obtained through the medium of a questionnaire to be filled out by the members of one's own faculty. It is highly important, however, that careful judgment be exercised in the selection of those who are to coöperate in making the course evaluation. Not only is it desirable to obtain the opinion of those

SUMMARY OF EXPERT OPINIONS ON TIME REQUIREMENTS FOR TEACHING SELECTED COLLEGE COURSES

Course	No. of Usable Replies	For the First Time Teaching Course Average Minimum Hours Per Week					After No. of Years Teaching Course Average Minimum Hours Per Week					Discipli. Ability Needed			Ability to Motivate Needed		
												Figures Show No. of Replies Indicating Each					
		Prep.	Cor.	Student Conf.	Staff Cons.	B'kk'g	Prep.	Cor.	Student Conf.	Staff Cons.	B'kk'g	Less	Avg.	More	Less	Avg.	More
Analytic Geometry	21	8	4½	2	1	½	3	3½	2	½	½	2	14	5	1	7	13
Freshman Chemistry Lectures	20	8½	0	2½	1	1	4	0	2½	1	1	3	9	8	0	5	15
Freshman Chemistry Laboratory	20	4	6½	2	1	1½	2½	5	2	1	1½	1	9	10	0	8	12
Economics	22	11	4½	3	1	1	6	4	3	½	1	0	10	12	0	8	14
Electrical Machinery	21	10	7	2½	1	1	6	6	2½	1	1	0	10	11	0	2	19
English Composition	25	6	6	3	1	1	4	5	3	½	1	5	11	9	1	2	22
Heat and Air Conditioning	22	8½	3	2	1	½	5	2	2	½	½	3	18	1	8	12	2
Industrial Accounting	19	9½	3½	2	1	½	4½	3	1½	1	½	1	12	6	0	8	11
Graphics I	25	7	5	2	1	1	3	3	2	½	1	2	13	10	3	7	15
Strength of Materials	33	10	4½	2½	1	1	5	3½	2½	½	1	4	22	7	5	12	16

Compiled from questionnaires submitted by 228 teachers in colleges and universities throughout the U. S. A.

FIG. II

now teaching the course, but also the opinions of others who are competent to evaluate it. Moreover, both administrators and teachers should be asked to coöperate. Their approaches to the problem will naturally be different, and may quite likely reveal factors that would otherwise be overlooked while together they will derive a keen appreciation of each other's problems. The number of separate evaluations any institution will deem necessary must of neces-

ANALYSIS OF TEACHING LOADS IMPOSED BY SELECTED COLLEGE COURSES ON EXPERIENCED TEACHERS

Course	No. Students	No. Student Sections for			Class Hours Instruction per Week	Sem. Hour Equiv.	Prep.	Correction	Student Confs.	Staff Consult.	B'k'k'g	Out of Class Time Required of Instructor	Total Time Required of Instructor	Ratio of Total Time Requirements to Sem. Hr. Cred.
		Lec.	Lab.	Rec.										
Analytic Geometry	30	0	0	1	5	5	3	3.5	2	.5	.5	9.5	14.5	2.9
Freshman Chemistry Lectures	75	1	0	0	2	2	4	0	2.5	1	1	8.5	10.5	5.3
Freshman Chemistry Lab. and Quiz	75	0	3	3	12	6	2.5	5	2	1	1.5	12	24	4
Economics	120	1	0	5	7	7	6	4	3	.5	1	14.5	21.5	3.1
Electrical Machinery	60	1	3	1	12	8	6	6	2.5	1	1	16.5	28.5	3.5
English Composition	30	0	0	1	3	3	4	5	3	.5	1	13.5	16.5	5.5
Heat and Air Conditioning	30	1	0	0	3	3	5	2	2	.5	.5	10	13	4.3
Industrial Accounting	15	1	1	0	5	3	4.5	3	1.5	1	.5	10.5	15.5	5.2
Graphics I	30	0	1	0	6	3	3	3	2	.5	1	9.5	15.5	5.2
Strength of Materials	60	1	0	3	6	6	5	3.5	2.5	.5	1	12.5	18.5	3.1

Compiled from questionnaires submitted by 228 teachers in colleges and universities throughout the U. S. A.

FIG. III

sity depend upon the size of its faculty and the competence of those asked to coöperate.

In order to test out the use of Course Evaluation as a tool for educational administrators and to determine whether there can be a considerable degree of unanimity among educators in appraising courses, the authors tried out the plan experimentally with ten carefully selected courses representative of those that would be included in the curricula of many institutions. These selections were made to include courses with widely different objectives and content: courses typical of the elementary, advanced, and professional levels of study; those illustrative of the laboratory, lecture, exercise, and recitation method of conduct.

Each course was clearly defined in the manner previously described. Five hundred Course Evaluation Questionnaires (50 for each course), together with copies of these definitions, were sent to qualified individuals in over 200 colleges and universities asking their coöperation in the project. Replies were received from 228 teachers and administrators, whose average experience in their special fields was over ten years.

Summaries of the data they supplied are tabulated in Figs. I, II, and III. Careful analysis of these tabulations will reveal much of interest to individual readers. Space does not permit presentation here of more than those general conclusions which are significant because they challenge accepted practices in this field:

I. When a course is carefully defined there can be a meeting of minds among experienced teachers and administrators regarding what it requires of the instructor with respect to the following:

   1. Academic and professional education.
   2. Professional and teaching experience.
   3. Time required for its satisfactory conduct, whether the instructor be a beginner or an experienced teacher.
   4. What is demanded by way of discipline and motivation.

II. The time required for the successful conduct of a course bears no significant relation to the semester hour credit carried by the course. Educational administrators have generally assumed that an instructor will need to devote approximately three hours of time for each semester hour assigned him. Of this about a third is usually given to class work and the other two-thirds to preparation, correction, etc. Figure III shows that the ratio of total time requirements to semester

hour credits is never less than 2.9 to 1 and it may be as high as 5.5 to 1.

III. The great variation in the requirements imposed by different courses reveals the unfairness to individual teachers, as well as institutions, of establishing any standard of faculty load in terms of semester hours.

IV. The evidence indicates that lecture, recitation, and laboratory class hours cannot be arbitrarily equated on the basis of a general formula for all courses.

V. Because the load factors of preparation and staff consultation will not vary directly as the number of sections, appropriate allowance must be made for these in computing the total load of an instructor who carries more than one section of the same course. For example, Figure III shows the total load imposed by one section of Analytic Geometry to be 14½ hours. Three sections of this course would probably require no more preparation or staff consultation than one section; therefore, the load imposed by three sections would be 36½ hours.

VI. The time requirements imposed on an instructor who is offering a course for the first time are appreciably greater than those imposed on him in subsequent years by the same course.

Summary

Although educators have long been aware of the inadequacy of the various methods used for the measurement of faculty service loads, with the result that many attempts have been made to devise more satisfactory techniques, as yet no plan has been evolved that is both effective and practicable. Some proposals, though fundamentally sound, have proved too complicated to be workable. Others are simple enough, but no improvement over customary procedures. Present practice seems to be to measure faculty loads in terms of the traditional semester hour, or modifications of this unit such as the student-credit-hour, in combination with clock hours for the non-teaching load if this is considered.* But semester hours cannot be a satisfactory overall measure for every type of course; the varieties of content and objectives, the differences in groups to whom courses are offered, and the accompanying difficulties of presentation, make great differences in what is required of a teacher.

* See "A Survey of Proposed Units for Measuring Service Loads in Institutions of Higher Learning" by Schiller Scroggs, Bulletin No. 10, Oklahoma A. and M. College, October, 1932, for an excellent account of methods now in use.

The authors propose that education take a lesson from industry in this matter of evaluating the teaching job * by attacking the problem of faculty loads with the tools of modern management rather than in terms of traditional educational terminology. Specifically, they suggest that if an evaluation of faculty service load is to be meaningful it must be based upon a separate analysis of the various components which taken together comprise the work done by a faculty member.

This means that courses should not be parcelled out in semester hour lots to the members of a large faculty, but each unit in the curriculum should be evaluated in the light of its purposes, methods, requirements, and plan of operation.

* See "A Survey of Job Evaluation as Used by Industry in Determining Base Rates" by Asa S. Knowles and Frederic C. Means, N. A. C. A. Bulletin, Vol. XX, No. 7, December 1, 1938.

PRESENT TRENDS IN HEAT POWER ENGINEERING INSTRUCTION *

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The present trends in mechanical engineering as a whole have been the subjects of several recent papers.[1] From the standpoint of a single course the various writers seem to agree on the three following trends:

(1) a change from the practical and descriptive course to one which is more analytical, mathematical, and scientific in treatment;
(2) a correlation and combination of related subject material;
(3) a growing emphasis on the fundamentals of science.

Although these trends are interdependent, all three are worth consideration.

Heat power engineering is one of the most important subjects in any mechanical engineering curriculum. That this is so, is shown in the study by Carvin.[2] From an examination of the catalogs of the leading colleges the following average curriculum was set up:

General academic courses		43.8% of required class time
Engineering courses		56.2% " " " "
Electricity	5.5%	
Shop work	8.4%	
Thesis	3.7%	
Engineering option	2.8%	
Hydraulics	2.8%	
Heat power group	13.0%	
Machine design group	20.0%	
	56.2%	

The heat power group includes laboratory courses as well as lecture courses in thermodynamics, power plant design, refrigeration, in-

* Presented at meeting, Pacific Southwest Section, S. P. E. E., December 28, 1938, University of Santa Clara.

[1] "Looking Ahead in Engineering Education," F. L. Eidmann, S. P. E. E. JOURNAL, Oct. 1937. "The Ideal Engineering Curriculum," H. N. Davis, *Mech. Engr.*, Feb., 1929. "Aims and Objectives of an Engineering Education," *Mech. Engr.*, Aug., 1937. "Applying Science and Engineering to Education," N. E. Funk, *Mech. Engr.*, May, 1937.

[2] "A Fundamental Course in Mechanical Engineering," F. D. Carvin, S. P. E. E. JOURNAL, Dec., 1937.

ternal combustion engines. The basic course in this group is generally called heat power engineering and is given in the student's junior year. This paper considers in detail this basic course.

The subjects covered in this course vary with the school, the teacher, and with the textbook. However, since the purpose of the course is to lay the foundation for the specialized courses in several fields the following subjects are generally covered:

1. Thermodynamics.
2. Thermodynamic properties of fluids.
3. Ideal or pattern cycles for internal combustion engines, compressors, and steam power plants.
4. Heat transfer.
5. Combustion.
6. Physical construction of various types of engines and equipments.

It should be noted at this point that the list of subjects desirable for inclusion under each of the above headings grows continually. The effect of adding new and additional details is exemplified by the expansion of one of the prominent texts in this field from one volume in 1915 to three volumes in 1930.

Applying the three trends already noted to this course, the following points are noted: the deletion of all descriptive material is impossible since very few students have any first-hand experience with the equipments to be considered, a point which several of the newer texts have ignored. The correlation of subject matter is exemplified by the chapter on combustion in the newer texts. This chapter now generally contains the material scattered through the chapters on steam boilers and internal combustion engines in the older texts. The growing emphasis on fundamentals is seen in the expansion of the material on thermodynamics and on heat transfer. Thus the three general trends are found in the subject matter of this course.

Considering the various subjects included in the course in heat power, thermodynamics occupies the most important place. It is well to note that the development of this subject from an engineering viewpoint is recent. For example: the steady flow energy equation is not found in texts more than 15 years old; the correlation of the thermodynamic properties of steam on a firm theoretical basis was accomplished only 23 years ago.

Further developments in engineering thermodynamics are possibly foreshadowed by the periodical literature. For instance, J. H. Keenan [3] undertakes to supplement the concept of thermal ef-

[3] "A Steam Chart for Second-Law Analysis," J. H. Keenan, *Mech. Engr.*, Mar., 1932.

ficiency with that of the "effectiveness." The reason for this lies in the apparently inconsistent fact that the overall efficiency of several stages of a steam turbine may exceed the individual stage efficiencies. The underlying reason for this inconsistency is that the properties of steam permit an increase of availability of mechanical energy with entropy. Keenan defines the effectiveness as

$$\text{Effectiveness} = \frac{\text{Work}}{\text{Decrease in availability}}.$$

The decrease in availability is evaluated in terms of a new thermodynamic function

$$b = h - T_0 s,$$

where h = enthalpy,
T_0 = lowest available temperature,
s = entropy.

Using this "effectiveness" it is found that the lower pressure stages of a turbine are more effective than the higher pressure ones if the efficiencies computed on the usual basis are equal. This scheme is seen to be based on the Second Law of Thermodynamics rather than upon the First Law as is the older concept of efficiency. The value of this concept may warrant its inclusion in the future developments of engineering thermodynamics.

For other developments in thermodynamics attention is called to the increasingly great use of chemistry demanded by modern design. In the field of power plant design and operation alone, many of the present problems are chemical in origin. For instance, intelligent study of water treatment requires an understanding of the solubilities of gases and salts in water, and of the equilibria of such solutions at various temperatures. Analogous situations exist in the study of furnace combustion and in the study of heat treatment of boiler steels. Chemists have been very successful in applying thermodynamic reasoning to similar situations. Goodenough and Felbeck [4] have applied similar methods to the combustion in gasoline engine cylinders. Since the publication of their bulletin, various points made therein have appeared in heat power texts. It is reasonable to anticipate that the more general treatment of this subject will be included in the future development of engineering thermodynamics.

The subject of the thermodynamic properties of fluids has developed beyond the stage of mere statements of the perfect gas law and definitions of the steam table quantities. Where in older texts

[4] Goodenough and Felbeck, Bulletin No. 139 of the Engineering Experiment Station, University of Illinois.

separate chapters are devoted to gases and vapors, some of the newer ones have ventured to include both phases in a single chapter. Further, many substances other than steam are dealt with, thus rendering the treatment more general, and, hence, more useful. In addition, material with respect to thermodynamic inter-relations is being included, possibly due to the recent activities in vapor table formulation.

In the subject of power plant and engine cycles, the trend must follow practice since here the effort is to explain and improve existing cycles of operation. The internal combustion engine cycles have been discussed quite at length in periodical literature, chiefly because of the unreasonably high efficiencies obtained on the "air-standard" basis. The version of Ellenwood, Evans, and Chwang [5] involves the use of variable specific heats of gases to produce curves and tables for performing point-to-point calculations on these cycles. The great labor involved in such calculations is suited more to a specialized course than to a general course. However, the trend is apparently away from the simplicity of the old "air-standard" analysis.

Heat transfer has become important so recently that very few texts include an adequate treatment of this subject. As in the case of combustion, the ideas involved in heat transfer were scattered through the various chapters on heat transfer equipments in the older texts. The trend seems to be toward the treatment of heat transfer as a separate basic subject.

As already intimated, the subject of the physical construction details of engines and power plant equipments has been eliminated from some of the newer texts. In such cases either an introductory course in the sophomore year is presupposed, or the student is left to obtain details for himself. The nature of the material hardly warrants a separate course so that instructors must supply the lack with supplementary material, such as specially printed class plates which the student may keep in his notebook or in the form of lantern slides. The latter solution is the less desirable as the student's notes are apt to be inadequate. Since the present-day student seems to have even less contact with machinery than did the youth of 15 years ago, who struggled hard to keep his Model T on the road, the omission of descriptive material is unfortunate. However, if the contents of text-books is an index to the trend, the heat power course of the future will contain little descriptive matter.

In closing, we note the following trends in heat power engineering instruction:

[5] "Efficiencies of Otto and Diesel Engines," by Ellenwood, Evans, and Chwang. *Trans. A. S. M. E.*, OGP 50–5, 1928.

1. Increased emphasis on the fundamentals; thermodynamics, heat transfer, and combustion;
2. A regrouping of material as classified under the fundamental subjects rather than under equipments;
3. An increased body of analytical material regarding the fundamentals.

These trends are based upon consideration of the text-books recently published, of current periodical literature, and of personal observation.

Case School of Applied Science.—Paul Leslie Hoover of Rutgers University has been appointed Professor of Electrical Engineering and head of that department at Case School of Applied Science. Professor Hoover will assume active duties at Case on July 1st, at which time Professor Henry B. Dates will retire from the chair of Electrical Engineering with the title of Professor Emeritus.

Professor Dates retires from active service after thirty-four years in the Case faculty, previous to which he had been Dean of Engineering at the University of Colorado. He will continue to serve for the present as Director of the Evening Division at Case. Under his direction the Department of Electrical Engineering has won international recognition in the field of electric lighting. Professor Dates has been for a number of years a member of the International Commission on Illumination and served as national president of the Illuminating Engineering Society in 1938. The now widely used I.E.S. study lamp was developed as a result of an investigation of lighting in college dormitories and fraternity houses which was conducted under his chairmanship.

WHICH PROPERTIES ARE SUFFICIENT TO DETERMINE THERMODYNAMIC STATE?

By ERNEST M. FERNALD

Professor of Mechanical Engineering, Lafayette College

The following quotation is purposely taken from the work of an eminent authority in order to emphasize that the point to which the present writer would call attention is mishandled in general rather than merely by minor authors. Fermi * writes, concerning any system composed of a chemically defined homogeneous fluid:

> For a given amount of the substance contained in the system, the temperature, volume, and pressure are not independent quantities; they are connected by a relationship of the general form:
>
> $$f(p, V, t) = 0, \qquad (1)$$
>
> which is called the *equation of state.* Its form depends on the special properties of the substance. Any one of the three variables in the above relationship can be expressed as a function of the other two by solving equation (1) with respect to the given variable. Therefore, the state of the system is completely determined by any two of the three quantities p, V, and t.

Epstein † and others ‡ § make equivalent statements.

A reasonable conclusion from the foregoing would be that when any of the pairs t and V, p and t, or p and V, is fixed, the state of a single phase of any homogeneous fluid is determined. This, however, is simply not true. For example, water slightly above and slightly below its temperature for maximum density may have the same pressure and the same volume, yet be at different states. Hence, p and V are not always sufficient to fix the state of a single phase of a homogeneous fluid, whatever may be true of the other pairs. The writer believes that teachers of thermodynamics might well give this point some attention, for the rather fundamental question which properties are sufficient to determine state is cov-

* E. Fermi, "Thermodynamics," Prentice-Hall, New York, 1937, page 2. The foregoing quotation is reproduced with the permission of the publisher.

† P. Epstein, "Textbook of Thermodynamics," John Wiley and Sons, New York, 1937, pages 3, 39.

‡ J. A. Ewing, "Thermodynamics for Engineers," 2nd ed., Cambridge University Press, 1936, page 277.

§ E. Schmidt, "Einführung in die Technische Thermodynamik," Julius Springer, Berlin, 1936, page 22.

ered by misleading statements or ignored entirely in altogether too many books.

The situation can be remedied by including among the fundamental formulations of thermodynamics the fact that when energy is added reversibly to a simple system (a single phase of any homogeneous substance) by work alone, heat-transfer being prevented, pressure *always* increases. Similarly, reversible addition of energy exclusively by heat-transfer *always* causes increase of temperature. That is to say, simple systems are *stable* with respect to reception of energy by each separate mode of transfer. When receiving energy exclusively through one mode, they build up resistance to taking in any more. This unvarying behavior we shall refer to as the Law of Stability.

Now, entirely apart from thermodynamics, the following is necessarily true:

X and Y are sufficient to determine Z only if unidirectional change in X or Y necessarily accompanies unidirectional change in Z during which the remaining quantity is constant.

Applying this to t, V, and the state of a simple system subject only to work and heat-transfer, we note that when state changes unidirectionally while V is constant (continuous addition or abstraction of energy by heat-transfer alone) the Law of Stability shows that t must change unidirectionally and continuously. Therefore, t and V are sufficient to fix the state of a single phase of a homogeneous substance. Similar examinations reveal that the pairs VU, VS, SU, and pS, are also sufficient. ($U =$ internal energy, $S =$ entropy.) On the other hand, the Law of Stability affords no ground for belief that any of the pairs pV, tS, pt, tU, and pU, is in general sufficient to determine state. If any of these last pairs is sufficient, it is due to the truth of some other generalization, such as the kinetic theory of matter.

Examination of current texts reveals that few, if any, give anything like a satisfactory answer to the important question, "Which properties are sufficient to determine state, and why?" Since the Law of Stability yields a clear answer so simply, we would probably do well to include it among the fundamentals in our presentation of thermodynamic theory.

THE EMBRYO ENGINEER*

By "PROXIME ACCESSIT" (F. N. STACE)

The path of the embryo engineer is by no means an easy one, as this excellent article giving a review of the work confronting a prospective candidate for the University Engineering degree will show.

Bitter disillusionment comes to many a young, would-be engineer. Of the large number who feel that they are called to this profession comparatively few attain their objective. As one who has only too recently been "through the mill" I can speak with feeling of the B.E. (Bachelor of Engineering) course and perhaps give some helpful advice to those about to commence it.

Preliminary Examination

The preliminary examination taken before entering the University indicates little of what is in store.

Apart from special papers in trigonometry and drawing it is similar to the ordinary entrance examination commonly called "Matric." But a great surprise is received in the first University year. The subjects are entirely mathematics and science. To be more explicit they are pure mathematics (algebra, geometry and trigonometry), applied mathematics (really elementary mechanics), the elements of calculus, inorganic chemistry and physics (consisting of heat, light, sound, electricity and magnetism, in addition to general physics).

Almost every engineering student wonders why all the mathematics and science are necessary and when he will commence drawing and the more technical subjects which better conform with his preconceived ideas of the course. In his opinion the year is dull, disappointing and, possibly, difficult as well.

But he who successfully survives this year and passes the intermediate examination has his feet well and truly placed on the first rung of the ladder to the coveted degree. Few, unfortunately, do so.

Two Reasons for Failure

The reasons for failure are twofold. First, the absolute necessity for sound mathematical ability is the downfall of many and, secondly, the change from the teaching system to the lecturing sys-

* Reprinted from *The New Zealand Electrical Journal* March 10, 1938.

tem is too sudden and traps all but the most conscientious workers.

According to the syllabus it is not a really difficult year, but, as the failures prove, it is a most dangerous one.

Anyone who has had the benefit of a good school grounding in mathematics, physics and chemistry should not find the subjects at all alarming with the possible exception of the calculus which certainly is a little bewildering. The fortunate boy who has already taken all the subjects for the Junior University Scholarship Examination merely has to refresh his memory and broaden his knowledge, but the unfortunate one who has just scraped through the engineering preliminary and has never done mechanics, calculus and perhaps, chemistry, finds he had a lot to learn.

But the greatest obstacle is the strange contrast between school and university, between teachers and lecturers.

Where University Training Differs from Schools

At school a boy is compelled to attend classes, it is his teacher's job to instil knowledge, the hours for work and play are rigorously defined and homework must be done. Then suddenly and almost without warning the school boy finds he is considered as having grown up. He is addressed by grey-headed professors as "Mister." He need not attend all his lectures which are scattered throughout the day and evening. The lecturers merely present and explain their subject and usually leave it at that. The student must learn it for himself by studying in his spare time.

And countless other attractions are offered him. A galaxy of clubs and societies entice his support, the social life of the University lures him from his work. It is only by great will-power that he can resist the temptation to enjoy himself at the expense of his study. Thus it can scarcely be wondered at if the newly emancipated school boy partakes of the attractive University life to the full until, too late, he realises his mistake, realises the truth of the oft-quoted maxim that an engineer has no time for other activities, does a frantic last minute burst of sweating and fails ignominously.

Though such failure may mean the repetition of a year's work the time in many cases need not be considered as wasted. Provided that the student does not become discouraged and change to an easier course (as is often the case) but has learnt his lesson and realises the necessity for honest and steady work with the minimum of pleasures, then indeed he may start afresh and should make sure and steady progress.

The Second Year Easier

The first year being successfully surmounted and the student having settled down at the University the second year should present fewer difficulties and should also stimulate his latent interest in engineering. There are, it is true, an alarming number of subjects, no less than nine in fact, but University examinations are taken in only five and of this but one, differential and integral calculus, should cause a conscientious student much trouble. "C2," as it is familiarly termed, is a real bugbear and fails many. The year, however, is a comparatively easy one, most of the subjects are interesting while several indeed are quite elementary. It is now too that the student feels he is learning to be an engineer.

Electrical Branch the Most Difficult

By this time he will have finally decided what type of engineering he will study. The majority take civil engineering, which has the largest scope. Electrical is generally regarded as the most difficult and highly specialised branch, while mechanical is the least popular owing to the comparatively few prospects of future employment it offers in New Zealand.

In the final two years of the degree course the subjects are very definitely engineering ones and vary according to the degree taken. The calculus is advanced a stage further in all cases but C3 usually seems to cause fewer failures than C2. Surveying and applied electricity are the two most dreaded subjects for civil students and the latter is also an obstacle in the mechanical course. To be successful in the surveying examination it is necessary to be fast and accurate with figures and logarithms. Lack of time is the complaint of most of the unsuccessful candidates. Applied electricity is another trap. For this it is necessary to know a little about everything electrical but apparently (though few seem to realise it) a detailed knowledge is neither expected nor required. Most make the mistake of concentrating on acquiring a more-or-less intimate knowledge of a few sections of the subject instead of a working knowledge of the whole. The electrical student has the greatest difficulty with the subject electrical engineering which is taken in two stages. An intimate knowledge of the design, testing and theory of both alternating and direct current machines is required. An ability to deal with tricky problems of all kinds is essential as these form an important part of the examination papers.

Difficulty of Finding Time

The greatest difficulty experienced in the two final years of the engineering course is to find time to study.

Laboratory work forms a large part of the curriculum and this entails a tremendous amount of work in the compiling of results and the writing up of "lab. books." Especially is this the case with electrical students who spend five times as long writing up the results of their experiments as they take to perform them in the laboratory. Indeed with two or three "labs." a week as well as lectures and drawing periods it usually means that every evening and most of the week-ends must be spent in writing up results instead of being available for much needed study, rest and recreation. Actually only the three weeks in October between the end of lectures and the commencement of examinations can be wholly utilised for learning the year's work so that it becomes a frantic race against time. By this stage of their course, incidentally, students have usually either given up engineering in disgust or else learnt to devote all their spare time, and more, to work.

Drawing Marathon

The last examination of all—the fifteen days' drawing and design—is a marathon. The student is told to design and draw a bridge, a motor, a crane or whatever the case may be. He may use any text-books and often spends hours, even days, searching the library for useful information and may work from 8 A.M. till 9 P.M. for fifteen days. Of recent years electrical students have found the time barely adequate though the others not infrequently complete within the time limit. Working ten to twelve hours a day, six days of the week, in a state of constant strain, certainly "takes it out of one" both physically and mentally. Thus it is not surprising that when the ordeal is over it is customary to celebrate in no half-hearted manner. It is, too, a consolation to know that failures in this examination are rare.

Qualifications for a Successful Student—Sacrifice of Pleasures

Having now sketched the outstanding portions of the B.E. Course I may as well conclude with a short discussion of the qualifications necessary for success so far as an engineering student is concerned.

A question often asked me is: "What made you take up Engineering and why did you decide on Electrical?" To take the first part of the question I can only reply that the profession appealed to me from the time I had my first Meccano set, and to the second I think it was merely the fact that electrical engineering by virtue of the few taking it and its obvious importance seemed to offer enough to compensate for its formidable syllabus.

But I quite realise that my answer is an inadequate one and even now I am not sure that it is possible to suggest any criterions by which would-be engineers could be judged. Certainly an interest in things mechanical is not enough. Sound mathematical ability is essential, combined with a large capacity for steady and honest work. The erratic genius, the intermittent dabbler, the dullard, or the slacker, have no place in the School of Engineering. One must be prepared to sacrifice all pleasures to attain the goal. As a degree is not awarded till eighteen months of practical work (in addition to the examinations) have been completed, it is customary for students to work each Christmas vacation and after completing the course, till the eighteen months have been satisfactorily disposed of. This means hard (and often unpleasant) physical work in the heat of summer when one's friends are enjoying themselves at the seaside. So it is hardly an attractive prospect, especially if the work is dirty and the wages are negligible. I am glad to say that I have heard of only two cases of students abandoning engineering owing to this phase of it.

Finally, I cannot point out too strongly that even when the goal is reached, the examinations and the practical work finished, and the degree awarded, no one should consider himself a qualified engineer and expect to find a lucrative job awaiting him. For his training is by no means finished. Indeed it is just beginning.

ENGINEERING EDUCATION *

By DUGALD C. JACKSON

Professor Emeritus, Massachusetts Institute of Technology

Editor's Note.—Although couched in terms of electrical engineering, this address applies equally to all branches of engineering.

The citation which the Edison Medal Committee has so graciously joined with my name couples engineering education with engineering practice. That never before has been done explicitly in an Edison Medal citation. Indeed the phrase engineering education never before has been used in such a citation. The use here seems to me significant of the present relation in the field of electrical engineering, where education and practice are now recognized as complementary parts of one whole; and it turns me to the theme of engineering education, to the exclusion (at this time) of discussing directly the science and art of electric-power practice which is the conjoined part of the citation.†

In the beginning of the last decade of the 19th century, electrical engineering was young and its devotees likewise mostly were young. As it usually goes in a young art, there was endless opportunity for exercise of the quality of quick creativeness, and therefore those of us who were in it were having all the pleasures and most of the perils of joyous adventure, with the reassuring result that the art was moving forward and expanding rapidly although the movement seemed slow to our ambitious minds. The responsibilities were large, but most of us were young and resilient and bore them satisfactorily as we pushed our way through the thicket of the partly-known or the jungle of the unknown.

While I was in the midst of this absorbing life at the opening of the last decade of the nineteenth century, there came to me from T. C. Chamberlin, then President of the University of Wisconsin, an invitation to visit him at Madison, the seat of the University—which I did. He offered me the faculty post at the head of a

* Response delivered January 25, 1939, upon receipt of the Edison Medal for 1938 from the American Institute of Electrical Engineers, omitting two paragraphs relating to the medal and the author's appreciation upon receiving it.

† The citation referred to is: "For outstanding and inspiring leadership in engineering education and in the fields of generation and distribution of electric power."

department of electrical engineering just authorized for the University. Madison was beautiful. It had expansive lawns shaded by many oak trees. Lively fox squirrels playing on the lawns and scampering among the trees added to the charm. The lake alone was adequate to fill the eye with beauty. I fell to the charm. The apple went to gain the fair Helen. But in spite of the precedent tribulations of Paris and the downfall of Troy, I never regretted the choice.

Chamberlin was a geologist of great intellectual power. Later as head of the department of geology at the University of Chicago he proved himself one of the nation's great scholars and of international fame. Before his time there had been some mild engineering instruction at the University of Wisconsin, but he gathered together a faculty group to cover the then principal branches of engineering. All of us, I think, had been successful as employees in engineering affairs relating to our respective branches, and some had been additionally proved in experience as teachers. We all were young. Indeed, some of us were scarcely dry behind the ears. I was twenty-six and head of a newly established department with no precedents to follow therein. It was early in electrical engineering and still earlier in organized electrical-engineering education. It was only six years since bachelor's degrees were conferred for the first time at Massachusetts Institute of Technology and Cornell University, which were the pioneer institutions in establishing formal curricula in electrical engineering. The A. I. E. E. itself was only seven years old.

By this time (1891) there were formal electrical engineering curricula in a considerable number of institutions, but substantially all had been established under the aegis of departments of physics and most of them still were directed by such departments. We were breaking sod in electrical engineering education because at the University of Wisconsin the department was established at once as part of an engineering school and coördinate with other engineering departments. That is the best of practice now, but it was irregular then. We owe a debt to the physicists for starting into electrical engineering education when they did, but later experience has proved the soundness in education of dealing with it as a coequal branch of engineering.

I refer to these things because they aid in showing the development of a philosophy of education in electrical engineering which seems to me to have had a considerable influence throughout the land. Chamberlin told us that, in the great plains area of the United States, college teachers of engineering were rather jeered at on the ground of being theoretical and consequently unpractical, and that we must maintain the proof of our competency in

engineering. This meant authorization for some practice as consulting engineers, which suited me, because (while I had previously carried responsibilities in engineering work) I could not be content to plan a way in engineering education without maintaining a continuing intimacy with the advancing front of engineering practice. That was more important in those early days than it is now, but the idea still possesses real vitality when properly applied.

Chamberlin was a scientist and he had an intuitive recognition of engineering as a profession relating to applications of the sciences and as being far different from even the highest order of artizanship. He expected us to prove ourselves scientists. We also had to prove a capacity for influencing students, which meant (for those of us who had not already done so) breaking into the art of pedagogy in a limited but important sense. The first of these was relatively easy for those of us who had laboratories or field duties under our control. We were young and full of queries as to why things occurred and about the interrelations of physical phenomena; and we used our students to work out our problems (for which we tried to make them competent) or to strip the ground for us so that we could dig at main kernels more directly. Incidentally, this was good pedagogy when used so as to put our students individually on their mettle, but I do not think we were aware of that. We were enthusiastically satisfying our own curiosity and our students' curiosity about physical relationships. We did get a reputation as a group of young engineers who were also competent young scientists and who attracted to them ambitious and resourceful students. This resulted in our growing group being frequently raided for the benefit of some other universities, to our grief at loss of colleagues but also to our satisfaction at such recognition of our serviceableness.

It was not so easy to gain acceptance in pedagogical lines from conservative members of faculty who cultivated the classics, philosophy, literature and other humanistic fields. However, various incidents arose that resulted ultimately in our acceptance in full as adequate members of the University faculty, and our relations were very happy. It was about this time that a near neighbor of mine, an authority in classical languages and literature, whom I regarded highly, said that he found me "very well read for an engineer." I had difficulty in convincing him that I could not accept that as the personal compliment for which he intended it because, if I did, it became such a sad reflection on my profession which we were trying to get people to realize is as much a field of learning as (for example) medicine or law.

Our engineering faculty group at the University of Wisconsin promptly went to work in defining our objectives and the programs for advancing toward those objectives. We explicitly formulated the understanding for the four-year undergraduate curricula that the objective was not to make engineers but was to make young men with "a great capacity for becoming engineers," since greatness in engineering usually comes with the years of wide experience. This, in my opinion, remains a good aim for the undergraduate curricula of the engineering schools, since too close attention to engineering practice prevents applying sufficient attention in the college to the essential sciences and political economy of which the applications make the structure of engineering. But I completely disagree with those who now urge that the tenet should equally apply to all graduate work in the engineering schools.

Our laboratories became more versatile and our library more extended as we struggled at Wisconsin to develop in our students individual initiative, self-reliance and resourcefulness by processes of self-education learned by them while absorbing the facts and interrelationships of science and political economy. We were quite unconventional, but the processes worked. The engineering school of the University of Wisconsin grew in a dozen years into quite a reputation for creditable achievements in engineering education. In directing this project of higher education leading into engineering some of us came to recognize that (in the words of the Apostle Paul) "There is one glory of the sun and another glory of the moon and another glory of the stars." Also that among teachers and students there could be indeed very few suns or moons, but of stars there might be many and of them we learned to remember that they may be infinitely varied in their brilliances, their tastes and their prospective effectiveness. "One star differeth from another star in glory" also said the Apostle, referring to tangible appearances. We thought of these words but applied them to the imponderable human characteristics of the individuals. It also led us to the maxim that each member of the growing electrical engineering staff in the University must be a master in a creative way of some particular aspect of electrical engineering, who also possessed a wide general knowledge and interest in all human activities and particularly in the activities of ambitious young men.

When things were well under way, we started some graduate work in electrical engineering, and perhaps a little in other engineering branches, still with the individuality of the students in mind. Then, after a time we took to re-analyzing the history, and

developed scope, of electrical engineering education and practice in this country and Europe, with the purpose of criticizing our own processes in the educational field and learning whether our emphases were wisely set. This led us to more and more treasure and encourage student initiative and independence in laboratory work.

After fifteen and a half years of this fascinating development work, it was my fortune to go to the Massachusetts Institute of Technology in the post of Professor in Charge of the Department of Electrical Engineering there to set up the processes established by the Wisconsin experience. At M. I. T. the course was the oldest in the history of electrical engineering, having been established in 1882, and it had a very distinguished background in its more than 600 alumni from 22 classes. Many of the alumni already held important places in the electrical field. The Executive Committee which controlled the Institute for the Corporation was composed of devoted and distinguished men, several of them being important men in the electrical field. It was a stimulating situation and the department, in staff and students, about equalled in numbers those to which the department at the University of Wisconsin had grown, but the equipment was not the equal of Wisconsin's equipment for fertile teaching and the space was cramped in some of its aspects.

The M. I. T. curriculum had become, with the course of time, over-conventional, and the department staff was endeavoring to do too much of itself instead of relying sufficiently on fellow departments in collateral fields like mathematics, physics, mechanics, thermo-dynamics and so on; which tended to prevent opportunity for the individual members to become creative masters in their own chosen branches. We promptly revised the curriculum with the object of enlarging student independence and individual vision. We substituted the principle of the continuity (unity) of learning in place of the bit-by-bit dealing with electrical engineering as a series of concrete, inadequately dove-tailed parts which was then fashionable and which has not yet been everywhere abandoned; and we cultivated an intimate coöperation with collateral departments. The great industrial activity of our neighborhood enabled us to cultivate closer relations with the industries than had been practicable in the middle west, and we gained great advantage from the generous advice and aid of important men in the industrial field. This was important because electrical engineering is largely industrial, if we think of industry as inclusive of the public utilities as well as of manufacturing and its concomitants. I think it also was a stimulus to the growth of that sense of responsibility

toward supporting sound engineering education which now is found in various industrial circles. It also ultimately led to the joint establishment of the clearly defined coöperative curricula in electrical engineering (in which the Institute and each industry concerned bear mutual responsibility for the educational procedures), which now absorb the attention of over one third of the electrical engineering students at M. I. T. In our teachings, we markedly emphasized the research aspects of the higher levels of engineering activities.

Here, as we grew and were granted more space and more funds, we came to understand that a suitably directed large department with many students of varied tastes and fine abilities may prove to be more invigorating to the individual students than a smaller department may be. But there are certain restrictions which must be recognized. The department must have allocated for its use both space and funds which, on the basis of per capita of students, are fully equal to those of the small department, and it must have a staff membership which is fully as large per capita of students as characterizes the small department. That staff must be a group of scholarly and creative masters, each leader being a notable specialist in his own sub-division of electrical engineering and characterized by enthusiasm for science and equal enthusiasm for encouraging the independence of students while passing on to them his own best qualities. It is this variety of contacts with notable men available in a well-directed large electrical engineering department that produces the notable stimulation.

The point which I emphasize is that in engineering education no curse rests on bigness because of bigness, any more than either a curse or a blessing rests on smallness because of smallness. In either case, realizing the fullest service for students and for the engineering profession depends on the educational statesmanship coupled with the scientific creativeness of the department. If that combination is adequate, a well-staffed and fully supported large department may be more stimulating to students of high grade than a small department. This applies equally to graduate students and undergraduate students in their individual accomplishments.

In such a department the highest success depends on the undergraduate classes being divided into small sections, selected according to the tastes and mental speeds of the students, honors groups being organized with prime responsibility laid on the members for their own education aided by seminars and sympathetic counselors selected from the staff, searching examinations being offered which cover as a unit the entire field studied, large freedom for self-chosen investigation being provided in the laboratories and (as they

advance) the students being encouraged to participate as self-reliant individuals in staff research. By these processes stimulus toward full self-development is equally offered for the infrequent suns and moons and the more frequent stars within a range of brilliancy, as they occur among competent students of engineering. For success in the adventure, each leading man on the staff must have mental qualities which give him strength in science, in scientific research and in the applications of science, accompanied with strength in pedagogical qualities that lead him to sympathetic interest in the intellectual progress of students; and there must be a spirit of coöperation maintained amongst the staff members, which is difficult in a group of individualistically-minded stars.

Such men are difficult to find for the staff. They are far scarcer than men with fine research capabilities in science or men with fine pedagogical capabilities, who do not possess the twin capacity. It has been my fortune to find among my colleagues many such unusual men to whom I am glad to express deep indebtment. I wish I could tell you about them and the manner of their achievements, but that would require a substantial history of the electrical engineering department of M. I. T. and particularly of its last thirty years, which would be a long lecture of itself. Space protected from the weather, equipment for extemporizing experiments in research, and a properly supported staff of men with the qualities described, under sympathetic leadership and freedom to carry on will result in a great engineering school anywhere; but not unfrequently the proper spirit is not there or the necessary conditions are not provided and the engineering school is but an aspiring, or (worse yet) an unaspiring, nebula instead of a glowing star in the educational firmament.

A fine, creative department is costly to maintain. A good engineering school spends more money on its productive educational work than it receives in tuition fees from its students, and any university chief-executive who believes that a great engineering school can be run at less cost per capita of students than a great medical school aside from hospital costs is supporting an unfounded supposition. One fault attaching to our engineering education is that a few of the universities which support medical and various other branches of education on a high level of scholarly fitness are willing to see their engineering schools lie in the neutral space of semi-professional, semi-artizan activities, with minor emphasis given to scholarly and creative qualities. Naturally, such institutions fail to secure (or keep) scholarly men for leaders in their engineering work.

One more word: In Love's Labour's Lost, Shakespeare said that

the prosperity of a jest lies in the ear of the one who hears it rather in the mouth of the one who makes it. That is a saying which possesses a germ of substantial truth and it is worth remembering in connection with the field of higher education. We, of this age, may paraphrase the statement and say that a teacher's contributions lie in the achievements of his students, just as the repute of a consulting engineer lies in the minds of his clients. In these respects either the consulting engineer or the teacher is but a catalyst and is not a direct factor in the reactions that occur, except to stimulate them in the origin, to encourage them as they grow, and to give them range. This point should receive more emphasis in the pedagogical aspects of our processes of engineering education.

EDUCATIONAL VALUE OF SCHOLARSHIP SOCIETIES *

By FRANZ SCHNEIDER

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The problem which confronts us in this matter is as complex as the problem of society as a whole, particularly that of a democratic society where all effort must be expected to be voluntary. It is also intimately linked up with the problem of incentives such as are the basis of a capitalistic system. Even communism is said to have been forced to modify its methods for the many because human nature works best when there is some concrete desirable objective to be obtained. Professors, too, have been known to work and publish only because promotions and increases of salary seem to lie that way.

We shall confine ourselves to the honor scholarship societies just now.—On the campus of Berkeley we have about 80 honor societies. Of these 80 societies only half have scholarship requirements; the others are strictly student-body or professional honor-societies. Perhaps there are too many of them, but we must again bear in mind the general tendency in a democratic society of getting together in small groups of special interests.

If we look at the "educational value" of these scholarship honor societies, we may make the following specific points, dividing them into two distinct groups: One as seen from the students' point of view, the other as viewed by society and by the university which represents society in this particular.

1. (*a*) To many a student the existence of an honor scholarship society has been a distinct stimulation right from the start, thus encouraging him without loss of time to put forth his best efforts. Then, after he was elected, his membership often urged him on to keep up his record. He felt he owed it to himself and to his fellow-members in the society; possibly he may even have striven to surpass his former scholarship average, incidentally thereby repaying society for its outlay.

(*b*) To other students coming from humble surroundings, it has meant a great intellectual awakening to have been elected to an honor society. At times it has even given them a real faith in

* Outline of a talk given before the Pacific Southwest Section, S. P. E. E., December 29, 1938, University of Santa Clara.

themselves and called forth in them the will to strive in earnest; up to then they had looked upon themselves as small fry that lived at the fringe of society, just as their folks at home lived in the poorer part of town and were nobodies.

(*c*) In the honor society itself, the pick of the lot get together at certain times for social gatherings and discussions of problems connected with their work, which certainly makes for further stimulation and the growth of a feeling of fine comradeship. If the society is a comprehensive one, such as Tau Beta Pi, the members, I understand, are glad to attend its meetings chiefly because here they can meet with other engineers in other fields. This cannot but help them to see their own field in a better light and as an important part of a greater unit. Tau Beta Pi, in this respect, can do more concrete good than Phi Beta Kappa, where under the present Berkeley method of election there is too great a range of interests brought together without relation of interests.

2. From the point of view of the university, the existence of a scholarship honor society is most desirable. It brings to a focus those very urges and ideals and accomplishments in humankind which have originally brought about the creation of universities, namely, the love of learning and the striving after knowledge in close association with others similarly minded. In an old university of the European sort where all the students are on a par with our present type of graduate students, an honor scholarship society would be quite superfluous because the students are of a similar bent and are all reasonably competent. But in our colleges we have to accommodate an untried and motley lot of youngsters, many of whom will not go beyond their bachelor's degree and who will pass their finals without particular distinction. It cannot be otherwise in a democracy where we must raise the general level of intelligence and comprehension to insure a better, a more understanding vote and a finer concept of civic duty than has been shown so far by our millions. Hence, our colleges must keep the doors wide open to give to thousands a notion of the history of thought and human struggles to prepare them better for their lives as citizens. In such a group, however, the scholarship societies must make apparent and must represent the spirit and purpose of the real university that goes beyond the average and routine.

I, for one, am quite conscious of the faults and limitations of our honor societies, but so far as I have been able to discover these shortcomings are tied up with the faults and weaknesses of human nature as such, and not least of all with the faults and limitations of the professors themselves who but too often lack those qualities which would make their good students better and their honor

societies a greater success. Of course, even for these shortcomings there are perfectly understandable reasons, reasons of temperament and of economics, but at any rate, the honor societies themselves are least to blame.

As a concrete suggestion I should like to say that the faculties should strive to bring these honor societies closer to themselves both from the human and the academic point of view. These honor societies should become to the professors means of giving to the future through these "above-average" young people something of their own richness and mellowness, if they have any such to give; and academically, these honor societies should be encouraged to become the articulators of student opinion and student suggestions for the improvement of the teaching they get. Even if none of their suggestions can be carried out, the faculty can, by knowing what is in their minds, give them definite reasons why it cannot be done; the students may not realize off-hand what limits the professor, but they will see it if they are frankly told, and that alone makes for real coöperation between teacher and learner.

For the societies themselves I would like to suggest that they live up to their initiation promises with greater earnestness and determination. If I am not mistaken, the members all pledge themselves upon entering that they will broaden their outlook beyond their special technical knowledge. That certainly should be done, or we soon shall have engineers who will know no more beyond their specialty than the average garage mechanic. Far be it from me to think little of a garage mechanic if he is a good one; but I cannot consider him a leading force in a democracy, such as I expect a college-trained engineer to be. It cannot be gainsaid that at present our engineers are not sufficiently encouraged to take courses outside their special field. Theoretically they can, because they have a number of elective hours to spend as they wish. But feeling rather strange in liberal arts courses and at times getting into a class of a dull teacher, they soon lose interest in those particular courses, the more so as undoubtedly their time is badly needed to finish a drawing or a problem in their major courses through which they hope to make a living later on.

The problem is not made easier when professors of engineering are utterly at loggerheads with one another as to what ought to be done. If some professors look upon the majority of students coming to their colleges as a herd of cattle that are not teachable under any circumstances, little coöperation can be expected.

Other professors of engineering seem to think that the average boy choosing engineering as his life's work has made evident by that very choice that he is not interested in spiritual values and could not be made interested in them because his whole nature

does not incline that way. These professors, therefore, consider most necessary for their engineering students a course in straight business English so they can at least write an intelligible letter to a business executive when asking for an interview. Some engineering professors are not strong themselves in history or general knowledge; hence they not only set a poor example, but worse than that, they often even ridicule this "culture stuff," perhaps combatting thereby a gnawing consciousness of inferiority and insufficiency within themselves.

One need not look very far to see that our engineers are not very fluent with their pen and that their English could stand considerable improvement; but those in the liberal arts who might be picked to teach them must not be men steeped in philology and scholarship of bibliography who often even hate the modern age of radio and telephone and aeroplane and represent a smug or haughty outlook upon their time. Those chosen to teach this special group of interested engineers must be especially alive and deeply social-minded; they must be happy to give what they happen to know, quite conscious that these engineering students know much on their side about which the liberal arts teacher may be quite ignorant, yet which may be of greater use and benefit to our society than what they have to offer. In this way only a proper spirit of coöperation between the various fields of human knowledge can be brought about for the benefit of all of us; only in this spirit can a democracy be made workable and worthy of the name.

NEW SITUATIONS CONFRONTING THE YOUNG ENGINEER *

By ROY M. GREEN, Consulting Engineer

Lincoln, Nebraska

Statement of the Situation

The value of an Engineering College is reflected in the quality of its product. The profession and the public are both expecting an ultimate product which will express itself in a general utility such as will produce an improvement in man's physical and social well-being. The profession is awakening to the fact that this ultimate result is more dependent upon an attitude of mind and soul than upon any other single element. This fact is being recognized today and is the reason why you are conducting this particular program. When this attitude of mind is possessed by all those engaged in engineering work, we may then proudly say, "we are members of the Engineering Profession."

A profession has been defined as an endeavor for which a man is willing to give up his life. In the ultimate, the preacher or priest is willing to give his life for the faith. The doctor gives his life for his patients. The soldier gives his life for his country. Should the engineer give his life for man's well-being? How many engineers have conceived this to be their obligation?

You have, in the past, been reasonably successful in planting the seed which has borne fruit in the form of such an attitude of service in the minds of some of your graduates. Your proportion of successful results will doubtless drop off unless you find a more effective means of gaining this objective. The difficulty of your task has been tremendously increased in the past few years through a change in conditions over which you have had no control.

These changed conditions have affected the philosophy of the boys, have created a different attitude in the student body, and have made their imprint upon the actions of the Young Engineer. For clearer presentation and later discussion, let us divide the problem into three general headings.

1. The Boys; prior to registration in the college of engineering.
2. The Students, while studying engineering courses.
3. The Young Engineer, after graduation.

* Given before the Kansas-Nebraska Section, S. P. E. E., at Lincoln, Nebraska, October 22, 1938.

The Boys.—It should be recognized that, by and large, people tend to be conformists. Human beings, of all ages, tend to fit their philosophy into those conditions which *seem* to prevail. For example, you may repeatedly tell your children, "Cleanliness is next to Godliness." If you never changed your shirt, if your good wife never swept the floor or washed the dishes, or if you never took a bath; would you expect your children to be clean? Regardless of your constant reiteration of this axiom your children would remain filthy until their later experience showed them that filth was not an acceptable condition. People make their actions conform to what *they* find true conditions to be. This is a fortunate condition of human conduct, but in our present question it becomes a stubborn fact which must be taken into account if we are to face the truth.

You may say that your engineering students are a cross-section of the population of your state and represent the attitude of our people. This is not the whole truth but is probably near the truth.

When this country was passing through its pioneering stages the engineer, who located and constructed the new railroads, and who pioneered in the development of new lands, became the background of many thrilling and romantic stories. These stories so caught the imagination of the people that many adults, to this day, still picture the engineer as sighting through his transit, with his hat-brim turned back and waving signals to his helpers. Notice that this picture of the pioneering engineer was that of one who was serving civilization at great risk to himself. Much of his reward was his knowledge of services well performed. Notice, also, there were no political implications attached to his endeavor.

Contrast this picture with what the young man observes today. The common contact which every citizen has with engineers today, is that almost daily observation of the work of the WPA or PWA. An engineer has charge of this work, *in the mind of the populace*, whether this be true or not. Can you conceive of a boy being willing to give his life to a WPA project?

Another contrasting condition relates itself to the past and present ambitions of people in general. Only a few years ago it was popular to glorify the man, who, by his own efforts, was able to excel in a given walk of life. This was such a fascinating idea that a national magazine, of popular circulation, devoted almost its entire pages to stories of men who had succeeded. Success was measured by the attainment of preëminence in some line of endeavor, but usually in that of business and such success was often measured in annual income.

Contrast this picture of the glorification of preëminent attainment with the present feeling that a man is fortunate who can keep

off relief. A population, of which a large proportion is ambitious to "just keep off relief," is not inspired to attempt truly professional attainments.

In addition, there is a changed attitude toward the practical contact of the citizen with his government. It is true that the actions of our central government have always been moulded by the impact of pressure groups. The divisions of the past, however, have been largely founded upon very broad principles, such as a conflict between the agrarian and the industrial interests, and it was not so obvious to the citizen that we were being governed by pressure groups. Today, however, every thinking citizen is conscious of the fact that we are governed almost entirely by pressure groups. Therefore, to belong to the proper pressure group and to be on the inside is a profitable situation.

My personal contacts may be unfortunate, and may not be typical, but it seems that I have heard an increasing number of parents say, "I certainly want my son to go to the university because he can make so many valuable connections there." What are the connections for? So he may get along *easier*.

To say your present material is composed entirely of conformists to the present trend is obviously an error for you still get many jewels among the common run of stones. However, it should be evident that your task of creating the proper attitude for professional service has not been lightened by these general trends. Considering the background through which your material comes is it any wonder that many conclude that a good political connection is better than a sound preparation, or that membership in a labor union is better than membership in a professional society.

Unless some more powerful influence is exerted upon the young engineer, logic will make him conclude that a good connection is the goal of his endeavor.

The Student.—With his material, the teacher must discover and direct the potentialities which will finally result in the development of a professional man, and he has only four short years in which to exert his influence. The teacher is faced with very definite responsibilities in this short period of time. First, the student must be given a thorough understanding of the fundamentals of engineering. Second, through his studies, he should develop certain personal habits of honesty, thoroughness, accuracy, industry, orderliness, and should begin to develop a scientific attitude toward the problems he must later face. Third, the student should acquire a respect for his work. His respect should finally develop into a love for this work which will result in a willingness to make a real sacrifice in order to improve it.

In the past, the profession has expected the teacher, by him-

self, to achieve good results in all these efforts. However, the nature of these requirements are such that a part of them should doubtless be accomplished by a joint effort of the teacher and the profession, acting together, and this is now generally recognized by those who are informed.

In the first endeavor, that of developing a thorough understanding of the fundamentals of engineering, the task is obviously that of the teacher alone. This responsibility has been discharged with a reasonable degree of satisfaction in the past and doubtless some progress is being made toward better results in the future.

In the second endeavor, that of developing certain personal habits, the teacher should also accomplish the task largely by himself, being aided somewhat by the profession. The help the profession may give in this regard must necessarily be largely given after graduation.

In the third endeavor, that of creating a respect and love for the work the profession must assume its just share of the burden of carrying the responsibility, for it is obvious that the teacher's work in this regard may be entirely destroyed through unsatisfactory relations with the older men, after graduation.

The Young Engineer.—The period just following graduation is a time which tests the spirit and soul of the young engineer. He learns the world is not waiting for him with open arms. He learns he is not yet an engineer but is only ready to serve as a helper. He learns his prospective employers are interested only in what he can do and not to what fraternity he belonged, or where he graduated. If he is fortunate enough to get employment, he finds that his services do not demand a high rate of compensation. He also finds that the older men do not usually value his opinions very highly. In short, his position is seldom as attractive as he has been led to believe it would be.

Remember, however, that the young man is ambitious to get along, to be respected by his fellows. During this period it is not surprising that the young man again seeks a connection with something, or somebody, who can create pressure for him. He may try political pressure, or he may seek a group which poses as being able to create this pressure for him. Should he be blamed for this? He knows that much of the activity in engineering is related to some governmental agency. Government is subject to politics. Hence, political backing is sought. He knows that some results have been obtained through activities of unions, in other lines of endeavor, why should he not try? In this frame of mind he will probably return to his teacher, or if he is really down, he will blame them and not even visit them.

While you may all be familiar with the use of political pressure

for obtaining a favored position you may not be so familiar with the trend toward unionization in the engineering field. A brief outline of the national situation is of interest. There are two large unions, the Technical Engineers', Architects' and Draftsmens' Union, an affiliate of the American Federation of Labor, and the Federation of Architects, Engineers, Chemists and Technicians, now connected with the C. I. O. The Technical Engineers', Architects' and Draftsmens' Union is an old organization but was rather inactive until very recent years. Its early membership was largely in shipyards, navy-yards, and among civil service employees in some of the larger cities. There are now chapters in California, District of Columbia, Georgia, Maryland, Nebraska, New Hampshire, New York, North Dakota, Pennsylvania, Rhode Island, South Carolina, Virginia, Ohio, Wisconsin, and Washington.

The Federation of Architects, Engineers, Chemists and Technicians is a direct outgrowth of the NRA. It was started as an unattached group to attempt to influence the construction code, architects code, chemists code, and the engineers code under the NRA.

After a study of approximately one year, the Committee on Unionization of the American Society of Civil Engineers made certain recommendations to their Board of Directors, of which the following is a brief summary.

1. Membership in a trade union should have no more bearing upon a man's qualifications for membership in the Society than his religious or political affiliations.

2. The Wagner Labor Relations Act has encouraged the formation of new unions and the extension of old unions, and is now the law of the land. Subprofessional workers cannot be exempted from its provisions, hence it is not wise to attempt to amend the law so that Professional Engineers be excluded.

3. The Society, through the American Engineering Council, should support an effort to amend the Act so as to clarify the position of the subprofessional and professional engineer. This is to prevent the situation of having engineers forced into vertical unions where their identity would be lost and their interests forgotten, since the engineers would always be in the minority.

4. Existing unions are far from ideal to represent engineers in collective action. Experience has shown that such action can be taken by engineers, themselves, without resort to strikes and other trade union tactics. "It should be recognized that existing unions, despite their defects, are filling a need felt by quite a few engineers and many subprofessional men. Shutting our eyes to that fact makes it no less real. Unless the profession sets about to meet this need, at least for engineers, by some organization of

higher calibre than a trade union, it must look forward to extension of trade-union membership among engineers and the gradual transfer of engineering to classification as a trade rather than a profession."

5. To minimize the need for collective action by engineers, the Society should adopt and maintain an adequate and reasonably uniform compensation for the several grades of engineering employment. The Society should be prepared to site a member for unethical practice who pays less than the established minimum.

The original Unionization Committee was appointed for the purpose of preventing any ill-considered action by the Society, based upon a biased attitude. It has accomplished its purpose and a new Committee has been appointed to make more extensive studies so that constructive action may be taken. Such a study will be completed within a few months but it is obvious that no beneficial results can accrue from this effort unless local engineering organizations see that the information is presented and used in places where the need is greatest.

How May the Teacher Help in the Situation

The profession has a changed condition confronting it and must find a satisfactory solution. The teacher is an important element in the whole professional activity. If he is to do his work to its fullest extent, he must work with increased energy and extend his influence beyond the four years in which the engineer is under his direct supervision. He must strive to aid the boy, before starting, and be of greater assistance to the young engineer after graduation.

How may he accomplish the greatest results from his extended efforts? It would appear that he should join forces with existing engineering groups who are already in this field, such as the founder engineering societies, and especially their local units and the state engineering societies. Some of your members are now giving this service to the fullest extent. This number, however, is extremely small, in my opinion.

Being teachers of engineering, you all belong to the Society for the Promotion of Engineering Education. You take part in moulding its program and meeting its objectives. Being engineers, you should likewise belong to your local engineering societies and take an active part in moulding their policies. This is especially true now, because the program of these societies include so many activities upon which the success of your teaching activities rest.

Aid to Boys.—As a result of the inspiration of teachers, the

whole engineering profession is now directing attention to the proper presentation of the "Field of Engineering" to boys who may think they are interested in engineering or an engineering education. The great need for this activity is reflected in the high mortality among students from the date of registration, as freshmen, to the time of graduation; by the large number who graduate and then discover they are unable to rise above a sub-professional activity; by the great number who discover the activity is not satisfying to them because it is not what they thought it to be.

While the great need is easily recognized, the mode of procedure which should be followed in attempting to perform this service is not so obvious. The procedure is being given careful study and trial in many localities. Information on this important activity is being assembled and published by the Engineers' Council for Professional Development. Last month, their Committee on this activity distributed a "Guidance Manual" which they have called "The Guidance of Young Men Interested in Engineering Education and the Engineering Profession." This is an excellent piece of work for such an early stage in the development of the subject and I heartily recommend that every teacher of engineering make a careful study of it.

It has been my privilege to take part in several discussions of the problem of guidance, with a considerable number of men in practice. The opinions I find are, of course, extremely varied. However, an intense interest in the subject is always shown. Nearly always, the thought is expressed that this activity should be approached with caution so that over-promotion is not the result, for frankly, nearly all the older men in practice are of the opinion there has been an over-promotion in the past, and the teacher is blamed for this.

It is, therefore, very heartening to note the "Guidance Manual," referred to above, contains matter relating to many gainful occupations and not engineering alone. It also contains statements such as the following: "care must be taken to see that engineering is not over emphasized to the detriment of other professions and vocations represented in the community" . . . "engineering should not be presented alone" . . . "the possibility of 'overselling' should be avoided."

To present in detail and still not oversell may not be such an easy task. For example, it is noted in the report that the suggested blank which is to be used to assist the applicant in making a "wise choice" has, in the heading, these words; "Sponsored by the Engineers' Council for Professional Development." Again, the Guidance Manual recommends that the applicants read the booklet, "Engineering—A Career—A Culture." The first issue

of this booklet has been widely circulated, and criticized, and has been revised. However, this first issue contained a section on "Earnings of Engineers," which showed curves based upon the earnings of 20,000 members of the American Society of Mechanical Engineers. It also contained the statement, "You may assume that this study represents the entire engineering profession accurately enough for your present purposes." The reader of this pamphlet is a boy who has not yet started. In his present position he does not know whether he is going to even finish this engineering course. It would seem proper, at this stage, he should be told what his chances were of ever being good enough to even belong to the American Society of Mechanical Engineers. This statement is made with all kindness, and with an appreciation of the courage and forethought of those who were willing to undertake the task of launching this endeavor. It would appear that this manual should be constantly in a state of revision as its use becomes more general. I have been permitted to read the manuscript of the revised booklet on "Engineering—A Career—A Culture," which has not yet been printed. It is extremely gratifying to note that this is a much improved presentation.

The preparation of the data for this important part of the work is obviously in good hands. Corrections have been made, and more corrections will be made. Therefore, the real question before us this morning is, Shall we put this information to use? It would appear that it can best be put to use through the local engineering groups. They should be organized to do this and the teacher should be in the forefront in carrying the problems to the local societies. In short, the teacher must extend his influence to the future students if his work is to be effective.

The Student.—During the period of the most intimate contact with the engineer, the teacher, by tradition, concentrates upon the mechanics of the profession, the fundamentals of engineering. In carrying on this process, however, it should be remembered that the goal of teaching is inspiration, not information. Information should be used as the path to the goal. John Ruskin has given a definition of real education, which it would be well to keep in mind. "Education does not mean teaching people what they do not know. It means teaching them to behave as they do not behave. It is not teaching the youth the shapes of letters and the tricks of numbers, and then leaving them to turn their arithmetic to roggery, and their literature to lust. It means, on the contrary, training them into a perfect exercise and kingly continence of their bodies and souls. It is a painful, continual and difficult work to be done by kindness, by watching, by warning, by precept, and by praise, but above all—by example."

According to Ruskin, and I believe in the soundness of his position, if you wish thoroughness in the student you should be thorough; accuracy, you should be accurate; industry, you should be industrious; earnestness, you should be earnest. If you do not wish the student to use pressure, or a connection, to obtain his end you should not advocate a connection with any particular organization for personal glory or advancement. If you wish the student to make a sacrifice for his work you should also be willing to sacrifice. If you expect your graduates to recognize their obligations to the profession, in general, you must also recognize them and put this recognition into operation.

The Graduate Engineer.—In recognition of the teachers obligation to the profession, there is no more helpful way of expressing it than by extending your influence as far as possible beyond the date of graduation, with each of your students. Again this influence can best be extended through participation in the activities of the various local engineering societies.

If we are to help in preventing the young men from trying the use of pressure to gain their positions we must show them that this is not a logical method of procedure and that there are better means of gaining their end. To the young man who wishes to use political pressure to gain his position, it should be made plain that a proper connection may be very beneficial in gaining employment but it is only through performing satisfactory service that he may retain that employment. If this satisfactory service is not delivered it is almost certain that he will lose his position by the same pressure through which he gained it. It should also be obvious that the gaining of employment through political pull, instead of merit, is a positive detriment to the whole profession and the entire practice should be discouraged as far as possible. This can be done through a concerted action and the teacher, as well as the engineer outside the educational institution, should join in this effort.

Practically all the young men who have resorted to the union as a means of bettering their conditions have done this for economic reasons. The profession, at large, is to blame for this condition. We have not been aware of our responsibility to the younger men just starting in the work. If these young men knew that a group of the older men were aware of their situation and were trying to help, in a tangible way, much of this pressure would be relieved. The schools have largely assumed this responsibility and have performed good services in that connection. However, it would seem more logical to have this activity taken over by the local engineering societies so that it might be broader in its effects. If a graduate of Kansas State College comes into Nebraska he should

feel that more than his Alma Mater are interested in his situation. This work should be general and coöperative and not competitive, in the narrow sense.

In summation, if you are to be successful in creating the background for developing truly professional engineers, you must recognize two stubborn facts: Your material, with a few exceptions, has a changed philosophy which must be altered. It cannot be altered simply by exposing it to prepared conditions in college. If this philosophy is changed the teacher must assist the profession by extending his influence to the students prior to entrance in college and to his activities after graduation. Will you, as individual teachers, make this contribution to the profession?

CULTURAL TRAINING IN ENGINEERING COURSES*

By CHARLES L. BARKER

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To many, the words "culture" and "cultural training" have had a rather indefinite connection with an equally indefinitely defined education. This connection may have come about many hundreds of years ago when the expanse of knowledge covered by education was small. Then if a man possessed an education he was cultured. At that time the organization having to deal most closely with education was the church, so culture referred to something connected with the church. Education that led to culture was of necessity theological and the way to theology was through Latin.

The knowledge of science was Greek and before long scholars, cultured men, refused to be satisfied by the study of one source of knowledge, that of Latin leading to theology, but required the study of Greek, bringing science formally into education along with the great wealth of Greek mythology and philosophy.

Thus, the humanists, as they were called, won the day and the great reform which they effected was of incalculable service to mankind. However, as all reformers, after they accomplished the reform they strove for, they repulsed attempts of others to add to their educational plan.

This idea persisted for some hundreds of years through the middle ages and attempts to add any scientific discoveries of the middle ages to the general fund of educational knowledge were successfully repulsed. Hence, literature formed the basis of cultural training with the establishing of English, French, German and other languages and a literature of each, all were included in education. Education then became a study of literature. This thought persisted for years and is held by many at the present time.

The idea that perhaps scientific training might have cultural value is not new. Thomas Huxley, in his famous address on "Science and Culture," makes many statements directly applicable to our present time. It is his contention that culture demands general knowledge in all fields and *not* merely knowledge in the literary fields.

* Presented at a meeting of the Pacific Northwest Section, S. P. E. E., University of Washington, spring 1938.

Quoting from him, "We have here to deal with two distinct propositions. The first, that a criticism of life is the essence of culture; the second, that literature contains materials which suffice for the construction of such a criticism. I think that we must all assent to the first proposition. For culture certainly means something quite different from learning or technical skill. It implies the possession of an ideal, and the habit of estimating critically the value of things by comparison with a theoretic standard. Perfect culture should apply a complete theory of life, based on a clear knowledge alike of its possibilities and of its limitations. But we may agree to all this, and yet strongly dissent from the assumption that literature alone is competent to supply this knowledge." Continuing, Huxley states, "For I hold very strongly by two convictions. The first is that neither the discipline nor the subject matter of classical education is of such direct value to the student of physical science as to justify the expenditure of valuable time upon either: and the second is that for the purpose of attaining real culture, an exclusive scientific education is at least as effectual as an exclusive literary education."

Coming to this country in 1824, we find the establishment of the first non-military engineering school, Rensselaer Polytechnic Institute, first established to train science teachers, but with the advent of the railroad boom and the accompanying demand for civil engineers, the school became an engineering college. It was the first to receive the criticism in this country of no culture, all science—and yet the amount of engineering given at that time, compared to our present schedules was so small that I doubt if any more than a B.S. in Liberal Arts College would be granted now for what constituted an engineering education then.

We are, of course, all familiar with the changes of engineering curricula. The demands of the various fields have been so great, bridges, dams, power plants, engines, generators, transmission lines, all bigger and better than last year's models have forced the colleges to add more and more technical course work. These additions have been at the exclusion of courses which, perhaps, should not have been omitted. Now, we, as engineering teachers, are taking the place of Huxley. We are, many of us, defending the addition of more scientific courses. But we must remember that social sciences, economics, geography, etc., have also grown up. Perhaps we may be making the mistake of other reformers in the past. That is, refusing to continue to be reformers, refusing to raise our aims above the scientific fields and continue to demand the exclusion of the other courses which with our complicated plan of life are almost necessary to have the materials which suffice for the construction of a criticism of life.

In our present engineering curricula, we have a "full house" of technical courses and barely enough "to open" in non-technical courses. Then we have to augment our technical teaching if possible to develop the cultural side neglected in technical course work. Emerson, in his essay on "Culture," gives us several means to culture—education, books, companionship, personal accomplishments, cities, and solitude.

Coming to a definition of cultural training, that appeared recently. It defines cultural training as "improvement and refinement of the mind, morals and taste by systematic drill."

How can this be accomplished in our engineering courses? Notice the definition says nothing of subject matter, but rather refers to a process which the mind must pass through to have the desired result on any subject matter.

The organization of our courses in engineering with all the systematic drill should work for the improvement of the mind. However, the educational psychologist tells us that the amount of training to transfer from one situation to another is very small. That is training Johnnie to be neat in preparing his geography lesson will give his teachers no reason to expect him to be neat in arithmetic. If this is so, then can we expect the training from our logical presentation of a subject with lots of drill to carry over to the logical consideration of facts in Freshman Johnnie's mind? I doubt it. You ask your students a question to be answered with "yes" or "no," after he has carefully considered the facts involved. When you have his answer, ask him to give the reasons for his reply. Frequently he will give reasons for an answer opposite to what he previously gave. Many times I have asked this question: "Bill can do a piece of work in 4 days, while Tom does the same piece of work in 6 days. How long will it take the two together to do the work?" In typical W.P.A. style the answer comes back either "five" or "ten." We say that the student doesn't and can't think.

And again to our rescue comes the psychologist to further complicate matters. He states that it is as impossible to teach a man to think as it is to teach a dog to talk. This statement came from a prominent educator at an S. P. E. E. meeting. Then our task seems quite hopeless. However, at the same meeting, an old timer in engineering teaching with many years of teaching behind him said that he wasn't sure about this teaching boys to think—he really didn't care. But he said if we can't teach them to think, then our duty is to clean the dirt and sludge out of their already potential thinking minds so that the thinking machine could run and produce results. To do this, any course that requires the stu-

dent to do some work will help clean up the mess of dead knowledge that has been permitted to clog up his brain from the entertainment type of courses so popular at the present time.

Mathematics courses for freshmen engineers should be among the first that a student tries to help get his thinking machinery back into operation. But at the same S. P. E. E. meeting the educator who told us we couldn't teach a person to think suggested and had on display a new type algebra book. In his mind, it was a great improvement because it did away with the "drudgery" of problem solving. Several of us examined it. Three hundred odd pages. In the first one hundred and seventy-six, not a single problem.

In particular courses I feel that it is possible to give considerable cultural value and training for the taste as well as for the improvement of the mind and by so doing motivate the student. Interesting information about the men who are responsible for the laws you are studying is helpful. Many of the famous men of history were not just engineers, but were artists, historians, philosophers and doctors. Their knowledge was wide and it is these men who are responsible for the mathematics, mechanics and physics we have at the present time. The boys in mechanics and hydraulics, at least, show mild interest when you tell them that Archimedes was the founder of the nudist movement when he ran through the streets of Syracuse yelling "Eureka, I have found it." In studying pumps, the students all are interested that the Barber Ctesibus, over 2,000 years ago, designed the first valve pump and with money saved from haircuts and shaves built a pump that operated.

The near dead heat race staged by Newton and Leibnitz in the discovery of calculus, the articles on the slide rule by Delamin, and Oughtred and by Pascal on his computing machine, all in the old style of the 17th century are interesting and bits of information the student will never forget.

Dean Schlicter, University of Wisconsin, made this statement at an S. P. E. E. meeting: "The teacher cannot accomplish everything. Perhaps it is more in his power to enrich the personality of the student than to develop his mentality. The teacher can train the student in the facts of his subject; he can drill into him the technical skill required, he can develop in him proper attitude toward learning; and most of all he can train in him proper habits of work and self expression. But the teacher soon comes up against a stone wall. The God-given abilities of the student, the inborn qualities necessary to success the teacher can neither

create nor augment." In our engineering courses we have ample opportunity to help enrich the student's personality. Close intimate contact with individual students will accomplish much.

Finally, to quote from Professor Swain: "The aim of the college course is frequently said to be 'culture.' If I may define culture, I may admit that it should be the aim, but if the word means only an external smoothness and roundness of outline without regard to intrinsic qualities, it is a shame."

REVIEW

The recent addition of "Theory and Applications of Electron Tubes" by Herbert J. Reich to the McGraw-Hill Book Company electronic library of electronic texts is a definite contribution in this field. The title is truly descriptive of the character of this text. The text contains 670 pages, 9×12, and 512 illustrations. Price, $5.00.

The arrangement of the material is progressive, introducing the electronic tube, its structure and theory through the series from the simple diode to multiple electrode tubes. This is followed by analysis methods of tubes and circuits. This is followed by treatment of the functional applications of the more common types of tubes and a very detailed exposition of the theory and methods of the utilizations of the rectifying and amplifying properties of electron tubes as detectors, modulators, oscillators, etc. The important field of the electron tube as an amplifier is covered with exceptional thoroughness. A comprehensive treatise on electrical conduction through gases is followed by an extended presentation of the properties and applications of gas, vapor and light sensitive tubes. A final chapter is devoted to the applications of electron tubes in electrical measuring devices.

The style of presentation is such that it is readily followed by the reader. The some 670 pages of this text are essentially free from mathematical analyses which would present difficulty to the reader. This is accomplished without the sacrifice of thoroughness.

The book is exceptionally well adapted to giving the reader a working acquaintance with the varied types of electron tubes, their characteristics, associated circuits and applications. As a college text, it is well adapted to the requirements of the junior or senior engineering student. It will fill a definite place in the engineers' reference library.

G. A. Scott.

LOOKING AHEAD IN CIVIL ENGINEERING EDUCATION *

By F. E. SCHMITT

Editor, *Engineering News-Record*, New York

Thirty and forty years ago the technical colleges were doing excellent work in civil engineering education. In step with the progress of the art since then, they are doing correspondingly good work to-day, and have done so continuously in the intervening years. Proof may be found in the rise of the young graduates of ten, fifteen or twenty years ago, who by crowding their predecessors of earlier years gave evidence of more effective educational preparation. It may be found also in the continued advance of civil engineering performance and in the entrance of engineers into a multitude of industrial and public activities that formerly were the sole field of other groups.

In this situation we find little ground for questioning present practices in civil engineering education. As a matter of fact, when the colleges have been criticized or have been called upon to change their methods the reasons offered have usually been quite unsubstantial. Nevertheless, when we note how the pace of life and business has accelerated during recent years, and how the demands on every group of society have increased, we will be ready to admit that reëxamination of training processes is not untimely.

Change in Civil Engineer's Work

Consider for a moment how the civil engineer's work has been affected. In the early days he dealt almost wholly with technical problems in the narrow sense. He applied simple principles of mechanical science, together with intuitive resourcefulness, to rather definite questions adapted to quantitative answer. But since that time the vast expansion of civil engineering activities has multiplied the range and number of his problems. Many new fields have grown up. Knowledge and practice have become intensely specialized, and the volume of detail in each branch of the art has grown very great. Not only this, but the engineer has been drafted into many non-technical activities; he has come to be an important factor in executive and administrative work and has

* A paper presented before Middle Atlantic Section, S. P. E. E., at New York University, December 10, 1938.

been charged with many problems that go far outside the scope of technical considerations, from valuation and regulation to planning, framing public policies, or laying out works programs.

In effect the increased complexity of human affairs has made every large problem an engineering problem, dependent for its solution on measured fact and on objective analysis and conclusion. Engineering method is essential to a satisfactory result; yet at the same time few such problems can be approached without an understanding of economic principle, of finance, of custom and law, or without a perception of human relations and often of political movements. In a measure this is true even of the narrower engineering problems. The planning or locating engineer who does not correctly gage population trends or the possibilities of residential growth is apt to miscalculate. The city engineer who studies a project for an enlarged water supply may fail unless he utilizes shrewd financial and political judgment as well as a live sense of public relations, in addition to his technical knowledge and insight.

Higher Standards

In future these complexities will become larger, and engineering work may be expected to broaden further. Even as we look at present-day conditions we see a demand for greater precision and fullness of the civil engineer's technical equipment, and also a demand for knowledge and judgment in many non-technical fields—demands that the college is but indifferently prepared to meet. It is still less prepared to provide the equipment that the future engineer will require. And if we consider that the real function of the college is to train not the man of to-day but the civil engineering profession of twenty-five years from now, we must conclude that every effort is warranted to set its standards higher.

With these conditions in mind, let us ask whether and how the present system of college education could be improved to meet to-day's requirements more fully and to prepare also for building a stronger future profession.

That the existing educational methods do have shortcomings is generally conceded. There is evidence in the progressive crowding of courses, in reiterated demand for addition of more subjects, in the often uncertain grounding of young graduates in the fundamentals of their essential science, and in the deficient breadth as well as thoroughness of their equipment.

Such shortcomings are often charged to deficient preliminary education; yet the college must depend on the secondary schools for its raw material. At other times they are blamed on the limited length of the conventional four-year course; yet modern con-

ditions of life clearly forbid holding the engineering aspirant unduly long in the scholastic atmosphere—he must get out into practical life as early as possible, preferably about the time he comes of age. It is a primary condition therefore that the college shall so manage its work as to develop the engineering student within the time of a four-year course.

Eliminate Wastes

If under these limitations the present weaknesses of civil engineering education are to be corrected, we must look for higher efficiency throughout elimination of wastes. I believe that there are some wastes—wastes of time and energy that can be avoided, with gain of time for more thorough technical training and for addition of various auxiliary or broadening subjects.

Three major wastes present in most civil engineering courses, in my opinion, are, first, the teaching of useless or idle subjects; second, confusing and deadening methods of teaching essential subjects, methods that fail to correlate them with the engineering objective; and, third, the perpetuation of subjects formerly essential but now either secondary or obsolete.

As to the first point, such unenlightening disciplines as descriptive geometry are outworn; they should at once be discarded. As to the second, mathematics and particularly calculus are usually taught as dead systems of mathematical deduction; they should be taught as necessary responses to vital engineering problems, on the model set long ago by Perry's Calculus for Engineers, a work unfortunately never copied or modernized.

Teaching Branches of Engineering

As to the third point, I question the practice of teaching applied branches of engineering, a practice introduced into civil engineering education many years ago, when it was considered necessary to fit the student for a defined, specialized job. The practice survives despite radical change in the conditions of professional work. Some schools teach water-supply engineering, for example, and others teach highway engineering, as though either one were different from any other engineering. Occasionally we even find subjects like building estimating. Students are more apt to acquire limitations than broadened abilities from such courses; they often emerge from them with a random accumulation of uncoordinated bits of knowledge and with hazy and doubting conceptions of mechanics, of precise reasoning, and of the use of the basic tools on which all their subsequent work will be built.

Valuable time can be saved by eliminating these wastes. In addition there would be a marked gain in the student's clearness of

understanding and ability to think in terms of engineering principle. The time saved might usefully be applied to subjects of the type of accounting, management, economics and public affairs. We observe every day that the well-rounded engineer is the one who succeeded in broadening himself in these subjects by self-study. He would be better grounded in them by being introduced to them in college.

Progressive Arrangement Useful

There is another present-day need, one which is partly reflected in the high ratio of eliminations found in most engineering colleges. The student who is forced to drop out is likely to have nothing to show for his time spent in college; yet his dropping out does not prove him to be unfit material for an engineering career. The world has need for many men equipped with less knowledge than that obtained in the full four-year course. We have every reason to expect that courses should be so planned—and except for pedagogical convenience and habit there is no reason why they should not be so planned—as to give the one-year student at least one-fourth as useful training, and the two-year student at least half as much, as the full graduate. Progressive arrangement of college training should be made an aim of curriculum planning. It will be valuable even when and if a system of continuation education comes into general use.

The preceding suggestions are limited to such revision of existing courses as would, without disturbing general arrangement or content, increase their time efficiency and their productivity. If it should be found practicable to apply them, the resulting course would develop a better grounded, more broadly equipped and more adaptable body of civil engineering apprentices.

Future Requirements

But it is not certain that such revision alone will be sufficient for the full demands of the future. Granting that in last analysis the entire educational result depends on the teacher rather than on curriculum; granting that the inspired teacher will develop a thoroughly trained engineering mind regardless of the specific courses of study assigned to him, and that the uninspired teacher will produce mediocre results with even an ideal set of courses; it still is true that a logical, natural selection and arrangement of subjects of study will improve the educational effect. As we look to future requirements, then, it is worth while to give thought to the inherent elements of the training program necessary to develop the civil engineer. Even a radical reordering of the accepted educational plan would be justified if it should promise to be distinctly more efficient.

Three Major Departments

The major departments of teaching and development required to prepare for a civil engineering career are three, as I see it. First is *training in the use of the essential craft tools;* associated with this we need, of course, a general orientation in the scope and objectives of civil engineering, and some preliminary exposition of the materials with which the engineer must work. Second comes *study of the fundamental sciences* and the auxiliary arts and knowledge groups. Third is the final department, *training in engineering procedure,* from definition of the problem to assembly of fact, analysis and conclusion.

Of course it is an essential part of the civil engineering spirit that the limitations of existing knowledge be well appreciated, and that the student be early imbued with respect for research and for further development of methods, to advance the resources of the art. This element, however, may be expected to flow out of the work in the three departments mentioned, if the educational process is properly carried out.

It does not seem impossible to develop an effective educational plan in conformity with such a grouping and sequence. The necessary elements are in large part contained in present courses, though not clarified, grouped and concentrated for best effect. Required changes will be mainly in emphasis, coördination and treatment, though doubtless some new matter would need to be added and other matter discarded. The nature of the rearrangement will become clearer if we take a moment to think of the content of the three departments mentioned.

Tools and Skills

The tools and skills that the civil engineer utilizes throughout his career, and that in many cases he must learn later by gradual experience and with needless mistakes and setbacks, cover a wide range. I emphasize them and place them first in the program of education because the engineer must be first of all a practical man.

Among them are measuring, weighing and sampling; computation, quick calculation, estimation and checks; mechanical calculation; drawing, sketching and lettering; writing and typing; tabulation and the interpretation of tables and statistics; curve drawing and curve analysis; map-reading; bookkeeping, interpretation of accounts and appraisal procedures. Not least important in this group is training in observation and memory, two faculties that usually develop at random and imperfectly, and that are fundamentally important to the engineer above all men.

Fundamental Sciences

On the fundamental engineering sciences, nothing needs to be said. The essential auxiliary sciences, processes and fields of fact also are well agreed on; they should in any event include the law of contracts, patents, property and rights.

On the applied side this department of science and knowledge should give the student a good working knowledge of materials, forces and phenomena (including wind, rainfall, wave and current action, wear and corrosion), of power generation and utilization, and of the elements of structures, from framed assemblages to earth masses. It should also deal with engineering machines and processes.

Engineering Procedure

The third department, training in engineering procedure, would perhaps be handled most conveniently by the case method. Its purpose should be to develop the faculty of reasoning from fact—precise where precision is in order, well judged where calculation is not directly applicable. It would supply the training that is most seriously lacking in the young engineer, namely the power and habit of outlining a required course of investigation, finding and assembling the necessary facts, marshalling these in calculation, design or conclusion, and arriving at the complete solution of the problem or else defining the limits of practicable solution.

A course so arranged, and stripped of present waste matter and applied engineering courses, should leave room for a number of subjects of study that the great majority of engineers will need in important degree in their later career. Among them are economic principles, relations of individual to community, matters of personnel and labor relations, organizational systems, government functions and regulation, taxation, accounting and finance, and administration, particularly in respect to operation and maintenance. And incidental to this the student should be given such aid as is possible toward acquiring a satisfactory command of the arts of writing and speaking.

These collateral subjects are, of course, subject to the same remark previously made concerning mathematics: They should be taught, where this is possible, in their specific relation to engineering problems rather than abstractly. So treated, they would integrate with all the other elements of the educational course and would contribute to building and strengthening objective thinking and comprehensive judgment.

THE TIME-STUDY ENGINEER AND APTITUDE TESTING *

By CHARLES A. DRAKE

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The United States Budget for 1940, as presented by the President on January 3d, contains this provision on page 742:

> No part of the appropriations made in this Act shall be available for the salary or pay of any officer, manager, superintendent, foreman, or other person having charge of the work of any employee of the United States government while making or causing to be made with a stop-watch, or other time-measuring device, a time study of any job of any such employee between the starting and completion thereof, or of the movements of any such employee while engaged upon such work; etc.

Regardless of how seriously you may view this restriction that is obviously designed as a safeguard for the millions of government employees covered by the Act, it points definitely to two highly important conclusions: (1) Time study engineers have failed to "sell" their techniques in certain high quarters, and (2) there is still sufficient doubt about the scientific validity of their techniques to make safeguards against them a matter of public policy. The redundant effect of such a provision in law is to bring these techniques under still greater suspicion in private industry.

For this result the time study engineers are not wholly to blame. Their education has been defective—one sided and incomplete. The responsibility rests with the engineering schools, but one sees very little activity on the part of the latter to discharge this responsibility in a realistic way. The consequence is that the training they offer covers only half of the area in which the time study engineer must operate, leaving his efforts half scientific, half trial-and-error.

Any adequate solution of this problem involves the reduction of this area of trial-and-error to one of sound scientific procedures guided by principles evolved from experimentation. The responsibility of the men now practising as time study engineers is to inform themselves on what has been done, how it has been done, and

* A paper presented before the Metropolitan Section, A. S. M. E., Engineering Societies Bldg., New York City, Jan. 30, 1939.

how they may extend and apply it in their own work. The responsibility of engineering schools is to further the basic research now so well started and clearly defined, and to make suitable instruction available to their graduates who go into the time study field.

The trial-and-error area to which reference is made is that of human individual differences in abilities and aptitudes significant for industry. As long as jobs are set up with a nice regard for the technical requirements of production but with workers assigned to those jobs on a trial-and-error basis, the work of the time study engineer will be only half scientific. It can only merit public confidence and scientific approval when this practice is ended. How may this be done?

It may afford a comforting alibi to assert that the engineer must wait for the psychologist to present the findings of basic research. This is neither true nor helpful. The psychologist has no monopoly on, nor vested interest in, such basic research. Moreover, psychological research being what it is, we may wait a long time for such results.

We have pointed out elsewhere * that psychologists will not be likely to make any marked contributions to the solutions of these problems for reasons that are inherent in the process by which students of psychology are selected and trained. The preoccupations of the psychologists, both in the graduate schools and out of them, with theoretical and clinical problems, niceties of statistical handling and inference, and lack of comprehension of—and sympathy with—the industrial problems, augur no help from this source.

There are at least two other reasons why such help should not be expected. Psychologists, in common with navigators, statisticians, accountants, and other technicians—harking back to the magicians, soothsayers, astrologers, and necromancers of old—like to create and perpetuate the illusion that their arts are singularly difficult, resting upon sciences obscure and revealed only to a chosen few. (This may even be true of time study engineers!) This very human tendency enhances their own self-esteem and bolsters their demand for social recognition. Consequently they coöperate rather poorly with the practitioners of other arts.

The other reason is the prevailing ignorance of the problems in the industrial field. When a man knows little or nothing about the field in which he is impelled—or compelled—to write or teach, he commonly produces a history of what others have done in that field, or, at best, he may undertake a more or less detailed description of materials and activities. Lacking both insight and a com-

* *Factory Management and Maintenance*, March, 1938.

mand of the techniques, he describes rather than explains, with his attention and that of his audience directed to the past rather than to the present and the future. This is a common procedure observed in the courses in industrial management, industrial psychology, and personnel management as they are usually presented in colleges of engineering; and in courses in occupations and vocational guidance as usually offered in schools of education. Textbooks prepared from the swivel-chair view of the activities in question, and slavish devotion to those texts by so-called teachers who can only keep one chapter ahead of the students, will not solve the problem.

The situation charged is not imaginary. Survey the texts available in the fields enumerated and you will find that they are predominantly of the type defined as descriptive. Try to find more than three texts suited to professional school use in any of these fields that are written from the "How to" and "Why" points of view. You may not find even one that presents a body of principles that will serve as a guide in practice.

Ask the publishers why this condition exists and you will get two answers. It is due to the limited market for expository textbooks, a condition brought about because of the limited number of teachers who can handle such texts. The other answer is that there are so few authors who can write an acceptable expository textbook. There are few so-called practical men with an adequate background of experience in the field who can generalize their rich experience and formulate principles of value for the guidance of others entering upon, or practicing in, that field.

One might expect that collaboration between practical men who cannot write, and academic men who can envisage the problems of teaching and can also write acceptably, would offer a neat solution. This situation is comparatively rare. Most of the better texts, as well as much of the better teaching, seem to be the products of practical men who have turned to teaching and research as a career later in life. But such men are usually handicapped in several ways under the existing conditions in professional schools.

There is the usually timidity of deans and department heads toward adding to their staffs men who might overshadow present jobholders who have certain vested interests to protect and established customs to preserve. Again, it violates the procedure, more common since the depression than formerly, of adding young men of limited experience at low salaries and having them work up through the academic ranks by seniority and favor. Moreover, such a procedure may introduce ideas and points of view alien to those long held by the recognized leaders and great names of the present self-satisfied faculty.

One can point without difficulty to departments in our professional schools that are largely staffed—and in some cases wholly staffed—by men who were former students certain to perpetuate the ideas of the man who heads the department. Such carefully chosen young men will not be likely to threaten the ideas of the master nor disturb the tranquillity of things-as-they-are.

The conditions enumerated seem to be the ones that militate against an early and vigorous advance in the area where trial and error still vitiate the science of the time and motion study engineer. They account for the lag of many years between the time of scientific discovery and the embodiment of such discovery in teaching practice. They explain the unwillingness of professional schools to expand their curricula to meet needs that have already become acute in their fields.

Since help at an early date may not be looked for from either the psychologists or the professional schools, what can be done by practicing time study engineers? There appears to be but one solution: They must familiarize themselves with what has already been done and carry forward their own investigations. They must learn the more elementary techniques of statistics and the principles that underlie the design and application of tests. And they must actually design and apply tests that are appropriate for the jobs they set up, then select suitable workers on the basis of the test results, place them on the jobs, and later check up on the success of their procedures. Only in this way may we expect early progress.

However, before the engineer can make real progress in this area, he must add to his mental equipment a concept that was not taught him—or at any rate not taught him in such a way that he can immediately apply it—during his college training. This is a concept implicit in all handling of the human factor, due both to the variability of behavior or performance as observed in the same individual from one point in time to another point in time, and to the differences in performances observed between different individuals. The concept is that of probable error.

You are undertaking to predict human performance related to industrial production so that you may control its application in your particular plant. In order to predict you must be able to measure and you must know the cause and effect relationships between what you measure in human abilities and what eventuates when the abilities measured are applied on the job. You will never, because of the nature of the human material you measure and the imperfections of your instruments, get perfect correspondence between what you predict and what you actually get on the job. But

by improving your measuring techniques and by extending your knowledge of the relationships between measured abilities and job performance, you will be able progressively to reduce your errors. You will not achieve certainty but you may readily accomplish a jump from a trial-and-error performance which now yields, by the best personnel interviewing techniques, only 15 per cent successes to a method which yields 80 to 90 per cent successes. A 400 or 500 per cent improvement is no mean accomplishment in any field of human effort.

MACHINE TOOL LABORATORY INSTRUCTION IN THE ENGINEERING CURRICULA

By FREDERICK H. THOMAS

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The place of shop instruction in engineering curricula has been under discussion for a considerable time. There can be no doubt of the validity of questioning the need of shops if they are of the type one too often finds.

There are two primary considerations. The first is whether or not shops are a necessary part of an engineering curriculum. The experience of the Armour Institute of Technology has definitely answered this point. The answer was obtained after they had discontinued their shops and had made a study to determine whether shop work should be permanently abandoned. The investigation covered a considerable period of time and contacts were made with a very large number of graduates and others with the result that an overwhelming majority were found to be in favor of shop work. The decision was therefore made to re-instate this work in the curricula with such changes as were found desirable in the course of the study.

The second consideration then becomes one of what should be taught, and methods of teaching. This will require a study of more or less local nature with regard to equipment available, time that is, or may be allotted to the work, and of the staff available. With this information at hand a start can be made at laying out courses that will suit the need of today's graduate.

To determine these needs we must investigate the work of past graduates in the light of what they have found to be their usable information. Here we are certain to discover a great variance. Fortunately, there will be few that will say shops are unnecessary, but most, if not all, will state the need for a different method from that to which they were subjected. We may also have to do some missionary work among the teaching profession which, for the most part, is not fully aware of the part it is possible for the shops to play in the general educational scheme in engineering. To most of its members shops are just places where students make things. Well—after all, that is what they did when they were students!

One thing we may take into consideration at the outset is that

the graduate will seldom become a machine operator. He will, however, have need for a knowledge of shop processes since he will inevitably come into contact with products that have been made, or made possible through the agency of machinery. He may have definite need for information as a machine designer or factory manager, or in a lesser degree as a farmer. One cannot conceive of any work where a knowledge of such processes will not be of some value.

The main interest of the writer being in machine tool work, the remainder of this paper will be primarily on this phase of shop work. Then, too, this is the phase which has received the most criticism.

The primary criticism is that machine tool teaching has been manual rather than mental training. Most instructors have tended to make manipulation of the machines to produce a piece of work the important item. This piece of work more often than not has been a single item related in no way to any other item which may be produced. In the process the student has learned to operate machinery in a more or less rudimentary fashion and that is about all he has learned. This is the thing which must be changed if instruction in this field is to gain the respect to which it is entitled. The shop must cease to be just a shop and take on the aspects of an educational laboratory where manufacturing processes may be demonstrated, where the student may obtain physical contact with production machinery, where process information may be presented, and where one may possibly find solutions to debatable questions.

If this is to come about it will soon be discovered that instruction of a classroom nature becomes a major part of the scheme. Here it is that machines of a type not found in the laboratory are best described and discussed, where the tooling equipment, types of work done, and production times are brought to the attention of the student. It will soon be found that there are many subjects related to machine tool operation that must be taken up if the results of the course are to be of maximum value. Some of these may be listed as: materials and their place in the scheme of manufacture, fabricating processes, design, production control with its related information on routing, scheduling, and dispatching, quality control with related information regarding part specifications, gages, and gaging practice. Nor can we leave out time and motion study with the application of the information obtained from these studies. Such things as these cannot be adequately taught in the laboratory proper but they must be tied in with the manual work in a definite manner so that the student can visualize their application.

The need for a change in the method of teaching has long been recognized but actual change has been from slow to non-existent in

too many of our schools. There are several reasons for this. The first is personnel. The teaching of shops is for the most part in the hands of men who are excellent shop men but who are not technically trained in a way that gives them the viewpoint which is so vital to a proper presentation of these subjects to the engineering college student. They have been manual training teachers too long to make the change easily.

We might well say that inertia is next at fault. Any change demands a great deal of time on the part of the personnel and since the urge must come from a real desire to do a better job of teaching, it is all too easy to let things go as they are until more time is available. The non-competitive system used in the majority of schools certainly does nothing to encourage a change, and therefore does encourage a static condition.

Not to be lightly considered is the pay rate for men in this type of teaching. Since there are so many without a degree the salary levels are distinctly lower than for other engineering teaching. The result is that it is difficult to obtain men who have the practical background as well as the technical even when business is somewhat below normal. Occasionally, we can find an applicant with these requisites and the desire to teach, but this is unusual.

We may list next the high cost of laboratory instruction. Since the best method of teaching will mean less time in the laboratory proper it will appear that the utilization of the equipment is decreasing. This will not show to advantage in any student hour cost estimates. With increasing enrollments this may take care of itself.

It also appears that shop laboratories in general, because of the type of instruction, type of instructor, and lack of understanding on the part of the faculty as a whole, are working under a teaching schedule which will not afford the time necessary to work out the best methods and keep them up to date. Shop processes are not a semi-static thing like so many other subjects but are constantly changing and improving. Any attempt to teach the same thing year after year without keeping abreast of the changes can never lead to a successful presentation. It is just this situation which has brought the shops into their present disrepute.

Time table schedules do not tell all the story of the hours put in by a competent staff member. Proper preparation with attendant reading in the field to keep up with new developments will take many hours each week. Proper presentation will mean other hours spent in grading of papers covering problems which are necessary to such presentation. Then the laboratory work does not begin and end with the bell for there is more preparation to be made before the class work starts to see that work is assigned and tools

and equipment ready for use. After the students leave the laboratory, it should be checked to see that it will be ready for the next group. Upkeep of laboratory equipment, design and manufacture of new tools and equipment, and supervision of student or mechanic help will absorb more hours per week. Then invariably one has other duties to perform which add to the total. The result is that even with a twenty hour teaching schedule, the normal forty-four hours is hardly enough time per week to accomplish all that should be done. And when the schedule is thirty hours, as occasionally found, it is impossible for one to do the grade of teaching that should be done and have any time left to do the type of work upon which advancement is usually based.

The writer believes that it is necessary to have a laboratory product which will permit tooling up to demonstrate manufacturing processes to whatever extent possible. This allows a practical application of tools, jigs, fixtures, and instructions to a job. It will provide a use for standard gages in inspection of product and will demonstrate the need of dimensional control with attendant facts relative to limits and tolerances, and clearances, and will indicate desirable methods of producing to the desired dimensions. It will also provide an illustration of routing or operation sequence. It is also possible to demonstrate time estimating and other phases of manufacturing costs. Many other topics of value can be tied in with a product of this type.

No system of one piece projects will ever provide so much material of a practical nature as a product which can be assembled into a working model or a usable product. One piece projects do serve as a valuable adjunct to bring out points not covered by the assembled unit.

Never must the production of parts be allowed to interfere with the instructional part of the work. Production of finished pieces must remain the most negligible part of the program. The how and the why are most important. If in a group of one hundred students not a single assembly is made but the desired information has been imparted and sufficiently absorbed by the group, success has been attained. But if one hundred assemblies have been made without imparting this information, then the work has been a failure. *Too many of our laboratories set up the mechanical product as an illustration of success rather than the human product.*

Lack of modern equipment is a handicap to any attempt to give the student an adequate understanding of modern processing. But since all schools operate under the same handicap the best possible must be done to demonstrate the general idea and depend on the spoken word, written material, and pictures to keep the subject up to date. This is where the time element comes in for the instructor.

It means that if he is to keep his material in proper shape for presentation he must read in his field constantly and make plant visitations whenever possible.

Schools near an industrial center have a distinct advantage over others in that plant visitations can be made and students can see actual production processes. These trips need not be limited to one long trip during the senior year, but can be taken as occasion demands so as to tie up theory with practice. Their location also enables them to secure more easily the services of men in industry as speakers at student society meetings. It also enables the students to attend national society meetings, thus gaining much desirable information at first hand.

Schools not near industrial centers are distinctly handicapped in presenting the subject of machine tool processes to their students. Much of this handicap may be overcome by interested instructors by making use of information which is available for the asking from any manufacturer who is interested in advertising his product.

It is obvious that if shop work is to take its proper place in the educational program and receive the respect to which it is entitled it will necessitate an entirely new conception of what should be taught on the part of many of those doing the teaching. On the part of those not concerned with the instruction, it will necessitate a new conception of the position shop work should have in the educational scheme. Much time must be spent by all concerned in determining course contents and by the immediate staff in adequately preparing themselves for the work. Changes in personnel may be necessary in many cases, and in every case, the inducement should be such as to attract men with the ability and background to carry out the desired program.

PRESENT STATUS OF SPECIALIZED COURSES IN CHEMICAL ENGINEERING *

By B. F. RUTH

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There are in this country and Canada approximately one hundred colleges and universities which offer the degree of Bachelor of Science in Chemical Engineering. Of this number only twenty-eight have been recognized to date as having curricula and teaching facilities worthy of an accredited rating under the standards set up by the Engineers' Council for Professional Development. The remaining institutions are presumably more or less actively engaged in revising curricula and improving laboratory and teaching facilities so as to secure an accredited rating as soon as possible.

Because the accrediting agency as represented by E. C. P. D. has no authority to impose restrictions or standardizations upon the subject matter taught, the choice of courses to be placed in the curriculum is left almost entirely to the individual institution. The choice of courses for a curriculum in chemical engineering presents a problem of particular difficulty due to the wide variety of subject matter available, and the lack of any general agreement as to what subjects are most essential to a strong fundamental course. The handicap that this lack of uniformity imposes upon chemical engineering in comparison with other branches of engineering is clearly reflected in the fact that out of one hundred or so most important colleges and universities, between 90 and 100 of the curricula in civil, electrical and mechanical engineering were accredited within the first two years of the operation of the E. C. P. D., whereas only 28 were accredited in chemical engineering.

A survey of university and college bulletins reveals that over forty different kinds of chemistry and chemical engineering subjects are offered as required or elective work during the third and fourth undergraduate years. If these subjects are arbitrarily classified as courses fundamental and non-fundamental to a chemical engineering training, it is found that all curricula contain from 50 to 100 per cent fundamental subject matter. Classifying this same material roughly into chemical engineering and non-chemical

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engineering subjects, the percentage of chemical engineering subjects varies from zero in several cases to over 50 per cent in many others. Strange as it may seem, this means that there actually exist so-called chemical engineering curricula which contain no chemical engineering courses.

Such an analysis strikingly reveals the desirability and need for the formulation of criteria which will help establish high standards in the chemical engineering curriculum. In this connection, our discussion today may help to establish criteria for the case of a particular class of courses—those dealing with the chemistry and technology of some particular type of chemical industry, such as paper, leather, petroleum, etc.

The existence of numerous courses of this kind would seem to indicate that there is a definite need for graduates having specialized training in certain fields. The question has been raised as to whether the chemical engineering curriculum provides an adequate training for students wishing to enter such industries.

This is a question that cannot be answered by a catagorical yes or no, since each industry and institution presents quite different problems. In a certain sense, no amount of college training will fit a student to return full value for his salary in any industry for the first few months of service. Large industries such as General Motors, General Electric, Bell Telephone, and many other smaller companies have met this problem by establishing training schools in which the college graduate receives a more or less formal instruction for periods varying from several months to a year. Even where no formal course of instruction is given, it is customary to break new men in by shifting them from one job to another until they become familiar with the work and find their proper niche.

Such industries prefer that any specialized training be left to them to give in their own manner and ask only that the graduate come to them thoroughly grounded in the fundamentals of his general field.

However, this type of training, desirable though it may be, is not often possible in the specialized chemical industries. Thus, the ceramic and metallurgical industries have need for men so highly specialized in these particular subjects that a single company could not possibly afford to support them during the training period necessary to gain an adequate knowledge of the field. The necessity of training men for these industries in colleges and universities was recognized and satisfactorily met so many years ago that we are now inclined to forget that ceramic and metallurgical engineering are professions which may be considered as specialized divisions of chemical engineering.

It is entirely possible that if the cellulose, sugar, paint, varnish,

and rubber industries had had need for a comparable number of men trained in the chemistry and technology of these materials, there might today exist a number of additional specialized branches of chemical engineering.

That this development has not occurred is probably due to several reasons: (1) these industries have never needed the services of a sufficient number of men to encourage the development of such curricula and (2) they often prefer that what specially trained men they do hire acquire this knowledge through graduate study and research after they have received a complete and fundamental training in the basic sciences. To this end, many industries cooperate with educational institutions by supplying the funds necessary to support graduate scholarships as well as the equipment needed for instruction and research.

Unfortunately this system has one disadvantage in that few institutions can afford to have men on their staffs who have sufficient industrial experience or specialized technological knowledge to properly teach and direct such work.

Perhaps the ideal solution of the problem of training men for highly specialized industries has been found by the pulp and paper industry of northern Wisconsin. Here a number of paper manufacturers have coöperated in the establishment of the Institute of Paper Chemistry located at Appleton, Wisconsin. The Institute is under the direction of a staff of men highly qualified as teachers and experts in cellulose chemistry, and like any university, is empowered to grant advanced degrees. By the offer of subsistance scholarships, students of exceptional scholastic ability are drawn from all over the country to carry out graduate study and research leading to the doctorate degree in cellulose chemistry. In addition to the advantage of working under men whom few universities could afford to hire, the Institute possesses a complete reference library devoted to cellulose chemistry, as well as laboratories containing all the latest and most modern paper making and testing equipment.

However, it is not my assignment to discuss the relative merits of post-graduate specialized training in private institutes as compared to universities and colleges. It is rather to present the results of a survey as to the number and nature of the specialized courses in the chemical engineering curricula throughout this country and Canada.

For the purpose of this survey a specialized course is defined as one dealing with the chemistry or technology of a single industry. The decision to utilize this rather narrow meaning has eliminated from consideration a number of courses such as metallurgy, gas and fuel technology, industrial analysis, analysis of oil, gas, and

lubricants, electrochemistry, water analysis and treatment, boiler water treatment, sewage and sanitation, etc., which, although in a sense constituting specialized courses, are nevertheless favorably regarded by many educators as essential to a fundamental training for chemical engineers.

In this survey three types of specialized courses have been recognized:

(1) Those consisting of four year courses distinct from chemical engineering, the graduates of which are not termed chemical engineers, but whose basic curricula for at least two or three years is nevertheless almost identical with chemical engineering (Six curricula).

(2) Those which consist of third and fourth year options in metallurgy, ceramics or petroleum refining (Three curricula).

(3) Those which consist of one or two courses offered as

(*a*) required work (Four curricula),
(*b*) electives (Seventeen curricula).

Detailed information as to the institutions concerned, nature of courses, credits carried, etc., has been listed in an appendix given at the end of this paper. These data were obtained by means of a questionnaire sent to the heads of departments of chemistry and chemical engineering of 149 colleges and universities but are also supplemented by the examination of approximately 170 different college bulletins.

At the beginning of this survey it was felt that proper determination of the status of specialized courses should include an opinion from both educators and industrial employers, as to their attitude towards the teaching of such courses. For this reason the questionnaire just mentioned asked the recipient whether he approved or disapproved of undergraduate specialized courses, and requested that he state his reasons. It was, of course, hardly possible to circularize industry in a similar manner; however, inasmuch as petroleum refining is the principal chemical industry in this state, and because courses in petroleum refining technology are found to outnumber any other in our survey, an effort was made to secure the opinion of employers in this particular field.

I regret that time will permit only a brief resumé of the facts brought out by the questionnaire. From 149 letters sent out, 129 answers were received, of which 28 made no comment other than that they did not teach specialized courses. Of the remaining 81, one favored and eighty opposed giving specialized courses as required work. Of the eighty, however, eight looked with favor upon the type of specialized curricula offered at Louisiana and Maine, where four year courses in special technologies have been developed

to serve the needs of large local industries. Sixteen others were favorable to optional courses where the location of the school, the temperament of the student, and the nature of local industry made it advisable to do so. A portion of this group approved of elective courses as a means of introducing the student to some special field of interest which he might otherwise never contact in school. A large number of the recipients of the questionnaire were sufficiently interested to reply at length.

The principal reasons for disapproving of specialized courses were as follows:

1. There is hardly enough time in four years to teach even the necessary fundamental courses.

2. If specialized courses are not offered at the expense of fundamental courses, they at least diminish the number of desirable cultural courses that can be given.

3. Industry expects and prepares to train college graduates each in its own line of work. It desires men, who after learning the necessary details, can apply their theoretical knowledge to industry's problems.

4. Undergraduate students are not ready for specialized training.

5. Specialized work merely trains technicians, possibly valuable to industry in subordinate positions, but handicapping them in their advancement to positions of responsibility requiring men with fundamental training.

6. There is no way of telling what industry men will enter after graduation. It is better to give them fundamental instruction so that they may enter any industry. Few students ever find work in the particular field in which they have specialized.

7. Specialized courses tend to be descriptive, giving information that could better be obtained by actual experience in industry.

8. Few institutions can afford the equipment or have available properly trained men to teach the technologies of specialized subjects.

A similar survey of the opinion of industry would have been most interesting and valuable. As it is, I am restricted to the opinion of the petroleum refining industry alone. Six of the largest refiners in this state were questioned as to their opinion of the course in petroleum refining, such as we give in the department of chemical engineering at A. & M. College. Since this course is essentially the same as that offered by other schools, it is reasonable to believe that the opinions of these particular companies constitute a fair cross section of the reaction of the industry as a whole to the teaching of petroleum refining technology in our colleges and universities.

The six companies questioned all stated that they ascribed very little importance to specialized training, believing that the four years of undergraduate work could be more profitably employed in thorough instruction in fundamental courses. Four of them replied at considerable length. Valuing as I do, the opinions of these men in industry, I shall give several excerpts from their letters. One writes ". . . I do not expect a university to offer a specialized course which would prove of much help to the graduate in his subsequent position in an industrial organization. I am of the opinion that the time spent in an attempt to furnish a specialized course in oil refining technology could be better devoted to fundamental information. . . . I personally consider that a specialized course may handicap the graduate rather than help him, for the reason that petroleum refining, for instance, is continually changing. What would be considered good technique one year may be obsolete the next. . . . In our system we place the new men under a director who is specialized in his particular field. . . . He has ample opportunity to obtain a much more thorough specialized course in this way than he would be able to obtain in the university. . . . My opinion is that it is the duty of the university to concentrate on fundamentals and de-emphasize the importance of the oil industry as the most desirable outlet for chemical engineers."

Another writes: "It is my opinion that it is never worthwhile to substitute a specialized course for a fundamental one. It has been my experience that the college graduate most likely to become valuable to the company is the one whose engineering course contained more of the fundamental and fewer of the specialized courses and who has had theory well entrenched by the problem method. . . . It is true that it often appears that the student who has specialized makes a more favorable impression and showing the first year because he is already familiar with the terminology and has a smattering of process knowledge. As a rule, however, this advantage will not last for more than one year, at the end of which time the man who has spent more time learning to think rather than learning details will begin to forge ahead."

A third opinion reads in part as follows: ". . . generally speaking, practical knowledge of laboratory and plant practice will be easily gained by the student after entering industry. Fundamental theoretical training, almost without exception, will not be gained later, and can be acquired much better in academic courses. . . . It is our policy . . . to avoid hiring engineering graduates for laboratory and inspection work, feeling that such men will not long be satisfied in such positions. Any training they may have in such work would be of little value, since each company has its own methods in which it will insist upon instructing new men.

Further, it has been our experience that men with little technical training or even high school graduates can be instructed quickly to do such work quite satisfactorily."

Still another writes:

(1) Very few technical men keep up with the latest developments in the fundamentals of their profession; nor do they seek to enlarge their mental frontiers in this respect. Hence, we feel that the so-called practical courses given in college are at the expense of the fundamental courses which are more important.

(2) Too few technical men learn to solve a problem by breaking it down into its fundamentals but tend to seek a solution which can be obtained simply by substituting values in a formula. It is probable that this is due to lack of sufficient time while in college to study these problems from a fundamental standpoint because a certain number of subjects must be covered and too much time is taken up with the so-called practical laboratory courses.

(3) Technological advances, especially in the petroleum industry, are so rapid that colleges are not able financially to keep their laboratories equipped with up-to-date refining and drilling equipment. Consequently, it would be profitable from an industrial point of view, if the time spent on learning the mechanical operation of outmoded equipment were spent in the study of fundamentals. Some of our most successful technical men have never studied engineering but have thoroughly grounded themselves in the fundamental principles of mathematics, physics, chemistry and physical chemistry, and have acquired the practical knowledge necessary in a very short time after being with the company.

Lest these excerpts create the impression that the petroleum industry as a whole is opposed to the teaching of petroleum refining technology, the following points should perhaps be emphasized:

(1) These letters represent the opinions of refiners who annually employ men from all over the country in numbers sufficient to make a formal training course worthwhile. The opinion of small refiners as a group might be quite different.

(2) They are opinions as to the merits of specialized courses as compared to courses which must be omitted for lack of time, but which might be more fundamental to a chemical engineering training.

In conclusion, it seems to me that the answer to the question "Is the Chemical Engineering Curriculum an Adequate Preparation for Specialized Industries" depends upon the answers one would make to the following questions:

(1) Does specialized training in the undergraduate years occur at the expense of more fundamental or more desirable cultural courses?

(2) Do specialized courses tend to produce craftsmen and technicians, who will eventually be less valuable to their employers than men who have had a thorough training in fundamentals?

(3) Is it not possible that the great increase in the number of chemical engineering students taking advanced degrees in specialized fields these days has removed to some extent the necessity for giving specialized training which may have existed a few years ago?

(4) Do specialized industries request the services of four year graduates with specialized training, or is the trend in favor of men with advanced degrees?

(5) Is it not possible that many of our specialized courses are holdovers from the days when chemical engineering still consisted of curricula combining engineering and the study of chemical technologies, and before the common identity of the unit operations and processes throughout these technologies had been recognized? Is it not possible that such courses are offered because educators have conceived it to be their duty to prepare students to serve the industries of the community rather than of the nation?

In my opinion the answer to the question "Is the Chemical Engineering Curriculum an Adequate Preparation for Specialized Industries" may be summed up as follows:

(1) In general the answer is yes, with the exception of the metallurgical and ceramic industries, where special curricula are desired.

(2) Other specialized industries no longer expect nor ask colleges and universities to prepare undergraduate students to enter any particular industry.

(3) The field of specialized training, where available, has been removed for the most part from the undergraduate to the graduate curricula. If specialized students are requested, it is from the latter class that these industries seek such employees.

(4) Colleges and universities can no longer afford to train undergraduate students to enter specialized local industries if they wish to meet the higher standards which are necessary when these graduates begin to compete with those of other institutions for positions farther afield.

Survey of Specialized Curricula and Courses

(Four year Ceramic and Metallurgical Curricula not included)

I. Curricula consisting of four year courses distinct from chemical engineering, but basicly related:

1. Johns Hopkins University; Gas Engineering. Same as chemical engineering curriculum except for three courses, totaling 10 credits (7 hours lecture, 9 of laboratory).
2. Louisiana State University; Sugar Engineering. Differs from chemical engineering curricula by three

courses in sugar chemistry totaling nine credits, and three courses in mechanical engineering totaling 9½ credits.

3. University of Maine; Pulp and Paper Technology. Differs from chemical engineering curricula to the extent of nine courses totaling 17 credits comprising 4 hours of lecture and 43 of laboratory.
4. Massachusetts Institute of Technology; Electrochemical Engineering. Accredited curriculum.
5. University of Pittsburgh; Petroleum Refining Engineering. Accredited curriculum. (In 1938 united with Chemical Engineering curriculum.)
6. Pennsylvania State College; Electrochemical Engineering. Accredited curriculum.

II. Curricula consisting of third and fourth year options in metallurgy, ceramics or petroleum refining.

1. Missouri School of Mines; Ceramic Engineering. A three year option comprising 18 special courses totaling 48 credits, 30 hours recitation and lecture, and 66 hours of laboratory.

   Petroleum Refining, two year option. Comprises two specialized courses totaling 10 credits; 6 hours lecture, 12 hours laboratory.
2. Oklahoma A. & M. College; Ceramic Engineering—fourth year option: two courses totaling 6 credits, 4 hours lecture, 6 hours laboratory.

   Petroleum Chemistry and Technology; one year option, comprising two courses totaling 8 credits; 6 hours lecture, 6 hours laboratory.
3. West Virginia University; Ceramics. Fourth year option, comprising four courses totaling 9 credits.

   Metallurgy. Fourth year option, comprising four courses totaling 9 credits.

III. Curricula offering one or two specialized courses in the third and fourth years:

A. As Required Work.

1. University of Louisville; Oil, Paint and Varnish Technology, 4 credits.
2. Michigan State College; Petroleum Technology, 2 credits, lectures.
3. Syracuse University; Petroleum Technology, 3 credits, lectures.
4. A. & M. College of Texas; Oil and Gas Technology, 5 credits, 3 hours lecture, 6 hours of laboratory.

Cottonseed Technology; one credit, 3 hours of laboratory and recitation.

B. As Elective Subjects.

1. University of Akron (no course in chemical engineering); Rubber Chemistry, 8 credits. Rubber Latex Technology, 2 credits.
2. University of Alabama; Pulp and Paper Chemistry, 3 credits. Ceramic Engineering, 3 credits.
3. Carnegie Institute of Technology; Cellulose, 2 credits.
4. Case School of Applied Science; Petroleum Chemistry, 3 credits.
5. University of Cincinnati; Industrial Bacteriology, 9 credits.
6. Iowa State College; Cellulose Industries, 3 credits.
7. Johns Hopkins University; Theory and Practice of Industrial and Illuminating Gas Manufacture and Distribution, 3 credits.
8. Kansas State College; Petroleum Refining Engineering, 3 credits. Paints, Oils, and Pigments, 2 credits.
9. University of Minnesota; Gas Manufacture and Distribution, 3 credits.
10. Oklahoma A. & M. College; Petroleum Chemistry, 4 credits. Ceramic Testing, 3 credits. Petroleum Technology, 4 credits.
11. Oregon State College; Petroleum Technology, 3 credits.
12. Rice Institute; Physico-chemical Aspects of Petroleum Engineering, 3 credits.
13. University of Nebraska; Petroleum Technology, 2 credits.
14. North Carolina State College of the University of North Carolina; Cellulose, 6 credits. Gas Engineering, 3 credits. Oils, Fats, and Waxes, 3 credits.
15. University of West Virginia; Oil Refining and Testing, 2 credits.
16. University of Maine; Pulp Technology, 2 credits. Paper Technology, 2 credits.
17. University of Maryland; Gas and Fuel Engineering, 3 credits.
18. Pratt Institute; Paint, Varnish and Leather Chemistry.

SPECIALIZATION—AN OLD QUESTION IN ENGINEERING EDUCATION *

By R. M. BOARTS

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The question of specialized versus generalized knowledge is one that has attracted the attention of students and teachers since ancient times. It is true that Noah, a practicing zoölogist of note, was not confronted with the problem. He was told to take all living creatures as his field of interest, but since his time the question of breadth of training and occupation has been important in the lives of his descendants.

Nor is the question one that affects only the more mundane occupations. The art of painting has its specialists, the Pre-Raphaelites, who argued that every leaf in a picture must be painted with exactitude. Painting has its exponents of generalization, the modernists of several different cults, who paint ideas so comprehensive and abstract that words cannot serve to transmit the idea.

The art of teaching follows, in general, the progress in the field which is being taught. The steps of scientific progress are well known—research on specific problems, then a generalization of the known facts, then a return to specific research to investigate discrepancies between the generalization and individual phenomena, then a new generalization, and so on. Physics is a well known example of this cycle.

Engineering, on the other hand, has not followed exactly this course. As an art, it was derived from Military Engineering; as a science it was derived from physics and mechanics. Always impatient at the delays in fundamental research, engineering took what generalizations were available and built around them a body of empirical data which applied to specialized problems. Here the tendency was toward a branching out of separate occupations, each with its jargon and body of empirical fact.

At times this procedure broke down, and it was found necessary to go back to more fundamental or generalized knowledge for a new start. Such a case was chemical engineering. The problems of the chemical industries were handled by industrial chemists and

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mechanical engineers, and each industry had its own system of morals and dogma. It became apparent that important generalizations could be made if the processes in the chemical industry could be examined by a more fundamental light. Not too fundamental, of course; more a statistical study of the grosser characteristics of the play things of the physicist. This led the physicist to regard the chemical engineer as a bull in the china shop. The other engineers regarded the chemical engineer as a physicist or chemist who had escaped from the nursery, but this classification was not regarded with favor by any of the parties involved.

So it was that the unit operations became important generalizations. With this example, other fields were examined. The field of organic technology is now struggling to put unit processes on this basis. Colloidal behavior called for another return to fundamentals. Whereas the books on surface chemistry were mere catalogs of phenomena fifteen years ago, they are now generalizing and classifying the knowledge.

For there is no doubt—the generalization of knowledge is power. Power to calculate and predict results from a certain set of conditions, and power to train students by condensing a vast collection of facts to a group of laws or procedures. Specialization in training may, in fact, be undesirable because it tends to limit vision. Yet specialization is necessary where art is ahead of science, or where an industry will not or cannot train their new employees. Such cases are the fields of metallurgy and ceramics, among others.

In engineering other than chemical, the trend toward generalization is evident. The rise of fluid mechanics as a substitute for hydraulics and soil mechanics as a separate study from structures is testimony that facts are being condensed into laws.

Generalizations are valuable because they allow factual material to be studied and put in separate compartments like the ingredients necessary for a cake. To solve a problem or construct a particular cake one combines a certain set of ingredients. The fact that there is more to the baking of a cake than the mere mixing of the proper ingredients is paralleled by the fact that ownership of a handbook does not make an engineer.

Much overlapping and duplicating material could doubtless be eliminated from our college curricula if the principle of generalized study of basic segments of engineering knowledge were generally substituted for process or specialized courses. Fluid mechanics furnishes, for example, the basic principles on which a student can attack problems in fluid flow, friction, heat flow, ship design, and other diverse problems. A well-known engineering educator recently stated that the curriculum in mechanical

engineering could be taught along the lines of unit operations with a probable saving in time and duplication in course material.

But assuming that it is desirable to substitute unit-type courses of generalized knowledge for specialized studies of, say, pulp and paper technology or heating and ventilating, there still are cases in which this cannot easily be done. There is a conflict of interests. Without analyzing too deeply the functions of a college education, the job of undergraduate engineering teaching certainly involves the following three objects, shown in increasing importanee.

1. To train the student so that he can enter the engineering field and hold his first job to the satisfaction of his employer.

2. To give the student a progressive and sufficiently orthodox course that he can enter and do satisfactory work in graduate schools operated under the accepted American system.

3. To furnish the student with a sound basic training on which he can build a career of increasing dignity and responsibility in his chosen field.

With the last two of these objects this paper is not concerned. In the first statement, however, is a case for specialized courses which cannot be ignored. It is common for educators to concentrate their attention on the problem of educating the student. The question is, however, much broader than this. First, the teacher must be educated—this must be generally recognized by teachers when fifteen hundred engineering instructors attend a single meeting of the S. P. E. E. Second, the deans and presidents must be educated. If this sounds like a difficult task, at least it is not unique. Industry has gotten along tolerably well in the last hundred years despite presidents and vice-presidents. Third, the students must be exposed to education. Fourth, the employers of the graduated student must be educated.

This last may be very important or of lesser importance depending on the student marketing area in which the university operates. Large employers of technical men do not normally need job classification education for they tend to prescribe the education for the other three groups. Small employers and employers not in the same market area with key industries often need to be educated in utilizing the technical graduate to best advantage. This process cannot be direct; it is often painfully slow. Meantime it is necessary to train the student to the demands of the local employer or else seek a wider market. In any event, the student must be trained to satisfy the employers with whom the technical school deals, for there is nothing so shop-worn as a left-over technical graduate.

The first of the three training objectives listed above, then, must

not be overlooked. If the employers within the marketing area of a school insist on hiring chemical engineers to do the work of chemists, and mechanical engineers to do the work of chemical engineers, then something is wrong with somebody's definition of these occupations. Nevertheless, this does not relieve the obligation of the university to furnish candidates for the various jobs of these employers unless the university chooses to seek other employers for its graduates. In any case, if men fail at their first job, the school is blamed.

Therefore, the presence of specialized courses in engineering curricula cannot be condemned of itself. Local demand may alter the case. Even where the instructional staff believes the specialized course is not for the best, it often cannot be abandoned. The remedy does not lie in killing a good market for paper technologists to enter a highly uncertain and competitive market for chemical engineers. The remedy lies in further education of some of the parties above.

The Engineers' Council for Professional Development wisely does not prescribe a standard curriculum. The engineer is becoming more of a scientist, as are those in many other occupations. Nothing should enter in the training that would tend to jell progress. The only safe procedure is to reëvaluate all courses every few years to see if generalization is in order or if it is time to strike out from generalization to particular specific developments based as largely as possible on fundamental fact. In this respect schools or regions must examine their own cases and not be led astray by educational waves of enthusiasm. Progress is change, but change is not always progress.

COMBINED ENGINEERING LABORATORIES CORRELATED WITH MECHANICAL ENGINEERING*

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The possibility of having all, or a large part of the engineering laboratories combined into one service department, frequently called the "Department of Experimental Engineering," has been the subject for discussion by engineering administrators for some years, especially since the year 1930. These administrative heads have been considering such a possibility because of the increased equipment and maintenance cost for the efficient continuance of the several departmental engineering laboratories. The increased demand and cost of special equipment for advanced work and some duplication of such equipment in the several branches of engineering, as well as the apparent over-lapping of laboratory course content, has been given as justification for the combining of all or a large part of the engineering laboratory work into one department. The purpose of this paper is to present some of the advantages and disadvantages of this all-laboratory service department in our engineering schools, particularly as it affects mechanical engineering.

The laboratory courses in mechanical engineering include experimental groups on manufacturing processes, machine design, materials, heat power, fluid mechanics, aeronautics, refrigeration, air conditioning, internal-combustion engines, and others. To show the correlation of the usual laboratory technique to the mechanical engineering class room instruction the following subdivision of the basic content of mechanical engineering laboratory courses may be made: Properties of Materials, hardness, strength, microstructure, heat treatment, viscosity, specific heat, thermal conductivity, heat of combustion; Production Methods, casting, cutting, forming, and welding of metals, tooling, time study; Instrumentation and Measurement, thermometry, gages, indicators, calorimeters, meters; Mechanics of Solids, statics, dynamics, vibration, power transmission; Thermodynamics, combustion, energy conversion, gases, vapors, paths, cycles; Heat Transfer, conduction, convection, radiation, evaporation, humidification, condensation,

* Presented at the Conference on Mechanical Engineering at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

counter flow, parallel flow, mean temperature difference; Fluid Mechanics, flow of air, steam, oil, and water, orifices, nozzles, lubrication, steady and periodic flow, acoustics; and Others.

The foregoing classifications have been made to show how laboratory instruction in mechanical engineering "cuts across" the correlated units of the other engineering departments. Because of the all-inclusiveness of the course content and the large variety of equipment required for effective mechanical engineering instruction, this department is particularly interested in the possibility of establishing or discontinuing the combined engineering laboratory.

The names of courses offered and the types of equipment used in some of our departmental laboratories are frequently similar; these names may cause a misunderstanding when presented to administrative officers for their consideration and approval. To illustrate this point I will use a specific course with its required equipment: in our Mechanical Engineering curriculum at The University of Texas we have a course called "Heat Treatment and Welding of Metals," this course is strictly mechanical engineering in descriptive content and actual presentation. However, if this heat treatment and welding course were described as a course which included the principles of metallurgy, metallography, hardness testing, microscopic examination, some photography, electric heat-treating furnaces, and electric welding, the departments of chemistry, physics, civil engineering, and electrical engineering would probably understand, but administrative officers might consider this description as indicative of considerable inter-departmental duplication of classwork and equipment. In reality there is very little repetition of other classwork in this course except the usual application of the fundamental sciences as is the case with other sequential engineering courses and the use of electricity as the most convenient heating medium.

Concerning equipment, if the civil engineering, petroleum engineering, or mechanical engineering department were to request an appropriation for an electric driven testing machine, cradled electric dynamometer, electric welder, or an electric resistor the nontechnical administrator might consider the request as possible duplication of similar equipment in the electrical engineering laboratory. Because of the uncertainty concerning the correlation of the courses and equipment required in the several departmental engineering laboratories, educational administrators may consider a Department of Experimental Engineering as a possible solution. In this proposed department the civil engineering, electrical engineering, mechanical, petroleum engineering, and possibly the chemical engineering laboratories would all be under one head

with the supposition that equipment, maintenance, and duplication would be reduced to a minimum.

In order to obtain definite information on this subject the author wrote to five high-ranking engineering schools, each located in a representative section of the United States. Various possibilities and combinations of engineering laboratories have been used or are now in effect at these and other schools. The information and opinions obtained in this survey will be presented and analyzed with no reference to the name of the school or individual contacted.

To my knowledge there is no school in this country where the chemical engineering, electrical engineering, or highway laboratory are in any *teaching* combination: each is a distinct unit at all schools. However, there is some correlation between the work given in the chemical engineering laboratory and that in the highway and sanitary work of civil engineering.

At one school the experimental engineering department supervised the materials testing laboratory, hydraulics laboratory, all heat-power, heating, ventilation, refrigeration, air flow, aeronautics, shop work, and heat treating for some years. This laboratory division carried out as far as possible the wishes of the heads of the degree-granting departments in giving work to their students. This inter-departmental coöperation seemed to function satisfactorily as the laboratory teachers did not question the work to be given and the responsibility of the course content was with the degree-granting departments. However, the laboratory staff thought that there were some things that could have been planned and executed better if they were allowed to follow their own ideas and frequently tried to dictate the courses of the other departments as well as the work in the laboratory.

In later years the head of this laboratory service department was also made head of the mechanical engineering department. In other words, one man was the head of the two departments. As there seemed to be no inclination to pay any additional salary for serving in this dual capacity he succeeded, after three or four years, in having the experimental laboratory work turned over to one of his associates. This arrangement continued until several years ago when, as a result of an educational survey, it was recommended that the experimental engineering department should become a part of the mechanical engineering department and that the name experimental engineering should no longer be used. The recommendation was based upon economy, primarily accomplished by the elimination of the head of the experimental engineering department. Again no additional compensation was given to the head of the combined departments.

The experience at this school of changing laboratory responsibility and the final decision to have the laboratory an integral part of the department seems to indicate that combined engineering laboratories are not only unsatisfactory but also uneconomical. This conclusion is contrary to the oft-expressed opinion of some educators that a combined laboratory would be more economical.

At another school there are independent materials testing and hydraulic laboratories in the C.E. and M.E. departments with different emphasis on the work given in each of the respective laboratories. In this school there is a reasonable grouping of the mechanical engineering laboratory work into a modified combined engineering laboratory which includes materials testing, hydraulics, steam power, gas power, fuel and oil testing, refrigeration, heating, ventilation, and metallography. Please note that shop work and aeronautics are not included here. This is a large school where considerable research work is being done.

Another modification of the all-inclusive laboratory is found at a school where there are seven different laboratory units doing work in one large building. For purposes of coördinated arrangement, space requirements, installation, and maintenance of all the laboratory equipment, a member of the mechanical engineering staff acts as the coördinating officer. He directs a staff of mechanics who do all of the necessary erection, repairs, and maintenance work for the adjacent laboratories but he is not concerned with the instruction being given by the other departments.

The mechanical engineering laboratory at another school teaches work in materials testing, hydraulics, steam power, gas power, refrigeration, and aeronautics; a separate department teaches shop work and allied subjects. Although the work offered is somewhat diversified and more inclusive than at many schools, this mechanical engineering laboratory should not be classified as a combined engineering laboratory.

Duplication of equipment should be prevented by coöperation between the various departments. The executive committee of one engineering school has the power to prevent duplication under the school organization rules. This function must be carefully and tactfully done or much harm may result. However, arbitrary transfer of laboratory equipment from one department to another, even to prevent duplication, may result in bitter feeling, in probable loss of personnel, and a decided drop of enrollment in the courses of the laboratory affected.

In the majority of engineering schools the individual laboratories, such as shops, materials testing, hydraulics, highway, heat power, petroleum, electrical, etc., are under the direct supervision of some degree-granting department. But a number of courses,

such as shops, elementary heat power, materials testing, and electricity are given as service courses for the majority of our engineering students and frequently these students are indiscriminately mixed in many of the laboratory sections. It is because of this similarity of pre-senior work that a certain grouping of engineering laboratories has been advocated.

Another reason for suggesting the combining of engineering laboratory work is the feeling that has been growing in some schools that this work does not have as much educational value in it for the time, money, and effort expended as do other types of instruction. In other words a reaction seems to be growing against the "learning-to-do-by-doing" methods used in many undergraduate laboratory courses. This has come about because many of our schools are being called upon to teach an ever-increasing number of students with restricted and untrained personnel, also with limited and obsolete equipment; hence the laboratories must be assigned and used with clock-like precision. Our work may be compared with the mass production methods of industry.

The field of applications is increasing very rapidly in all of the divisions of engineering; this expansion leaves fewer opportunities than previously for the individual teacher and student to work as may please their time and inclinations. Also, some of the more elementary laws and facts about materials and machines, which were partly or wholly unknown when laboratory instruction began in our schools, have become general knowledge and may now be found in our various textbooks. Because of the increased enrollment, more material to be covered, and less of the research-type of laboratory work, the whole procedure has become more of an aptitude training than a mental stimulus.

Many laboratory experiments soon become stereotyped and the results may be well known to the student before he begins the experiment; and the writing of reports on these experiments may be even less inspiring. The experiment or test is generally routine and arouses very little interest in the student because he knows that ordinarily no use will be made of the data obtained, whether the test is for determining the tensile strength of steel, the efficiency of a steam turbine, the heating value of a fuel, the performance of an electric motor, or the characteristics of a pump. Because of these necessarily fixed methods the laboratory work becomes purely routine and therefore is not likely to arouse much interest in the student and the preparation of the laboratory report becomes more burdensome than if the element of discovery or research were more evident. In this way some of our laboratory courses are lacking in interest and consequently lacking in their educational value to

the student. If conditions are approximately as I have outlined them, what shall we do about it?

About one-fourth of the work done by an engineering student toward graduation is done in the laboratory. The teaching costs, excluding equipment costs, are from two to four times as much per student credit hour for laboratory as for lecture or class room work; thus the cost for the laboratory training is from one-third to one-half the entire instructional cost of each engineering graduate. If the cost of the drawing and design courses were included the proportional cost would be considerably higher. The question arises, is there any justification for giving such a large proportion of high-cost laboratory courses, high cost in the time of the student and in the cost of instruction, unless the educational return to the student is evident?

Laboratory work is a powerful teaching tool, capable of producing large educational benefits, but it is costly both in time and money. But for various reasons it is tending to become less effective and probably should be revised to suit present conditions. To effect this transition or rejuvenation the following suggestions are made: (1) Change the outlook of our laboratory teachers and re-educate them to a new viewpoint of trying to arouse and maintain greater student interest, thereby improving the morale of all of our engineering work. (2) Produce intellectual stimulation. If laboratory work is to be fully justified, it cannot be justified merely on the basis that the student may "learn-to-do-by-doing." (3) Allow and encourage the more capable students to deviate from the regular laboratory courses and work on advanced projects. (4) Eliminate some of our preliminary experiments, incorporate them with some of the later more involved tests. Try new combinations and vary test procedure. (5) Confer with other degree-granting departments to determine suitability and effectiveness of your instruction for their students. (6) Better correlation of work between various laboratories and whenever possible have tests conducted co-jointly or sequentially with another engineering laboratory. (7) Foster better regard for laboratory instruction so that it will again be accorded as much recognition, both academic and financial, as any other type of instruction. It is expensive, but well worth the cost if proportionate educational benefits are realized. (8) The never-ceasing cry for more personnel and for modern equipment should be mentioned, as laboratory work to be effective must be taught in small groups and the instruction should be coördinated with present day engineering practice.

Having enumerated some deficiencies in our present engineering laboratory instruction with departmental control and having suggested possible corrective measures, it is now feasible to con-

sider more intelligently the possibilities of the combined engineering laboratory. Some of the advantages claimed for the combined laboratory are: less equipment and smaller maintenance costs by reducing possible duplication; better correlation of laboratory tests and reports; selective instructional staff who are primarily interested in laboratory and research work; desirable concentrated arrangements of correlated equipment; particularly advisable in a small school with not much laboratory equipment in the various fields and reduced personnel; similarity of laboratory work given in the first engineering courses offer possibilities of a unified course in the sophomore and junior years, with specialization limited to the senior year; reduced building space and minimized service costs for heat, power, light, water, etc.

Combining of our engineering laboratories under one head has the following probable disadvantages: The laboratory and lecture groups may get out of step with each other. The laboratory instruction may become one-sided by doing work on subjects in which the head or majority of the staff are interested. Too much administrative control may be required. This would be especially bad in advanced investigations, as often the laboratory help must build needed apparatus according to uncertain or very poor designs. This administrative control may cost more than the present interdepartmental laboratory duplication. Actual experience has shown that the combined laboratory department would try to dictate the work for the degree-granting departments and with sufficient staff members would soon demand either too many units or too much work per unit. The result is that there would always be more or less friction as to just what engineering work should be offered in theory and what work should be given in the laboratory. Combined laboratory possibilities may appear economical on paper but eventually it would probably prove as expensive as the operation of the separate departmental laboratories. There is considerable danger that interdepartmental experiments may be combined, shortened, and standardized to the disadvantage of the student instead of realizing the promised advantage. Specialized instructors would be necessary, and separate instruction would still be required for each degree group. As departments grow and become more diversified it is desirable to have men who are specialists in their fields to continually develop the department laboratories and correlate the class room work with the laboratory experiments.

Let us look over our resources and study our laboratory deficiencies before we apply questionable restorative measures; a combined engineering laboratory has been suggested but other alternatives with fewer uncertainties are possible. The physician with his medicine is required for the sick, but nature with some

simple home remedy will take care of many ills, real or imaginary. Just so with our laboratory work, a combined engineering laboratory may not be the medicine or tonic required to improve our engineering instruction. If used in time the home remedies or self-curative measures may assure the continuance of the rejuvenated departmental engineering laboratories. The eight enumerated suggestions given earlier in this paper may be considered as possible methods for improvement of our engineering laboratory technique, but there are other correlated factors which should be considered.

Our engineering schools are continuously being called upon to do more and more with less and less; hence to compensate for the inability to maintain quality instruction and to do justice to all concerned it may be necessary to restrict the number of students entering our engineering colleges, adopt the five-year curriculum, or establish a professional engineering school with rigid entrance requirements. Industry and business have universally reduced their hours of work, hence it is doubtful if we should continue our traditional policy of giving five years of engineering education in four years. However, let me remind you that a longer normal program may endanger our hopeful progress in graduate work. If the junior college becomes a widely established and recognized part of our preliminary engineering education, an additional three-year program would undoubtedly be required to get an engineering degree. Thus the junior college pre-engineering training would fit into our five-year program far better than into our present four-year curriculums.

We have come to feel that engineering has been more successful in approaching its objectives than any other branch of undergraduate education but serious evaluation of the effectiveness of our mutual efforts should be made more frequently. Adjustments in curriculum, personnel, or course presentation should be made in order to meet the ever-changing conditions in the broad field of engineering. The ideal laboratory instructor should be of the research type and also a good classroom teacher in order to correlate both types of engineering instruction. A man may be a good teacher if he devotes his major time to classroom teaching, or a good laboratory-research worker if he concentrates in that direction, but the chances are that he may not be much of a success at either if he divides his time between the two.

There should be more complete coöperation between the departments giving engineering laboratory work; two committees could work out some of our mutual problems. First, a "Committee on Engineering Laboratory Practice" should study the type of laboratory instruction and style of reports for the purpose of unifying and understandingly differentiating the practice throughout the

entire engineering school and giving these practices clearly defined and recognized form. Second, a "Committee on Engineering Equipment and Maintenance" should minimize or prevent duplication of apparatus for the various departments. This committee should consider the advisability of establishing a service department, under one of the major engineering departments, which would install and maintain all of the engineering laboratory equipment. The success of our efforts to better coördinate and improve all of our laboratory work depends largely upon the presence of congenial personalities in the key positions of each department, those who are willing to give as well as take.

In recent years there has been some discussion of the possibility of correlating more laboratory projects with the courses in machine design. Experiments, exclusive of shop laboratory work, assigned to undergraduates in the mechanical engineering laboratories deal almost exclusively with heat-power and hydraulic machinery.

A frequent criticism of machine design courses is that too little emphasis is placed on the dynamic loading of machine members and the stress distribution produced by such loading. To determine dynamic loads it is often essential to use laboratory methods. Basic machine laboratory work could include: bearings and lubrication, clutches, power transmission methods, critical speeds of rotating shafts, photo-elastic stress analysis, fatigue, tests of springs, vibration and balancing, and others. In many schools restriction of space, equipment, funds, and personnel have prevented the inclusion of this type of engineering laboratory work. If a better correlation of the laboratory and design work could be obtained, it would give our machine design courses greater stability and the so-called applied value which, to some extent, is lacking at the present time.

Various criteria for rating the relative standings of our schools have been used, such as enrollment of students, area of campus, age in years, number and size of buildings, value of equipment, capacity of stadium, number of faculty members, success of athletic teams, and other countable and measurable items. These features, which relate chiefly to magnitude of plant and multitude of operations, do not represent the most significant measure of any school or division thereof. A diamond is the queen of stones not because of size. Quality and excellence are more to be desired than quantity and size. The educational policies and the physical equipment of our laboratories should keep pace with the new engineering developments; they should advance to meet the new demands, not retrograde to a lower level. Undoubtedly our objective in laboratory instruction should be to stimulate the application of class room theories rather than to perform a series of standardized experiments.

There will probably be some changes in engineering laboratory work in the near future which will be in the nature of a division of some of the work that is now being done, and a better grouping of related types; this should eliminate some duplication, unnecessary expense, and effort. There is real opportunity for improvement in this direction but I do not believe that many proposed advantages would be realized by putting all of the engineering laboratory work in one unit.

CURRENT TRENDS IN PETROLEUM ENGINEERING*

By EUGENE A. STEPHENSON

Department of Petroleum Engineering, University of Kansas

Introduction

As nearly as the writer has been able to discover, the first work in petroleum engineering, as a specific educational program, was instituted by Roswell H. Johnson about 1912 at the University of Pittsburgh in the Department of Oil and Gas Production. In 1916 Professor Johnson and his associate, L. G. Huntley, published a volume entitled "Principles of Oil and Gas Production."† Although poorly organized, reeking with ambiguities, and insufficiently edited, this work nevertheless called the attention of geologists—Johnson and Huntley were consulting geologists—to many engineering principles which most practicing geologists knew existed, but had rarely utilized. Such ideas as "well spacing," "following up a discovery," "graphic presentation of methods of computing the results of offset wells upon each other," "methods of bringing in a well," "management of gas wells," "secondary recovery methods," "reports upon oil and gas properties," "valuation of oil properties," "the natural gas industry," "size and scope of oil and gas companies," constituted the major portion of this volume.

The courses offered at the University of Pittsburgh were based principally upon geology as given in the closely affiliated department of geology, hence the latter is really the foundation upon which Petroleum Engineering started. Professor Johnson was also much interested in statistical analyses and his students early developed the habit of expressing factual matter in graphic form. His blackboards covered the walls of several class rooms, and the students carried on continuous graphic records of oil prices, rates of production per day per pool, number of new completions in selected pools, pressure and open flow data as to gas wells, etc. Unfortunately, conclusions were continually—and frequently erroneously—drawn from insufficient data. A glaring example of these errors was presented by Johnson and one of his students in a criticism of the method of estimating gas reserves on the basis of the decline

* Presented at the Conference on Mineral Technology at the Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

† John Wiley and Son, Publishers, 1916.

in pressure per unit volume of gas produced.* The fallacy in the argument, which lay unexposed for many years, came through the use of an average pressure for the field studied, based on the sum of all the well head pressures divided by the number of wells represented. Failure to recognize the fact that the greatest declines in pressure were located in the same areas where the largest number of wells were concentrated, and that relatively small declines had taken place in much larger areas where few, if any, wells had been drilled led to the false conclusions, and left the problem of estimating gas reserves to those few individuals who were able to discern the fallacious reasoning and devise improved methods of obtaining correct average pressures for the fields.†

Later volumes by Jeffery, Suman, Uren, Phelps and Lake, Herold, and finally by Cloud have given us much better organized material,‡ with ample references to the publications of the American Institute of Mining Engineers (Petroleum Division), the American Petroleum Institute, *Industrial and Engineering Chemistry,* as well as the *Oil and Gas Journal,* the *Oil Weekly,* the *Petroleum Engineer,* and the *Journal of the Institute of Petroleum Technologists* (London).

It may be well to recall that the oil production industry started with virtually no technical assistance. It prospered at first in spite of its lack of skilled labor and trained personnel. With the passing of its pioneer phase, the geologist finally came to exercise his potency upon the rate of discovery of oil pools, although it was long after the fundamental principles of oil accumulation had been enunciated by Dr. I. C. White. Many of us can remember when the geologist was the butt of drillers' jokes, and when inquiries of the drilling crew were met with jeers or frigid silence. It is known now that in many cases the icy reception was the result of the driller's realization that these young college chaps had something which he did not have and that they also excelled him in the adept use of information which he possessed, but which he was reluctant to divulge lest his own ignorance be exposed.

* Johnson, R. H., and Morgan, L. C., "A Critical Examination of the Equal Pound Loss Method of Estimating Gas Reserves." *Bulletin of the American Association of Petroleum Geologists;* 1926, Vol. 10, pp. 901–904.

† Davis, Ralph E., Unpublished manuscript. The method was first described by Mr. Davis at the Pittsburgh meeting of the A. I. M. M. E., October 6, 1926.

‡ Jeffery, Walter N., "Deep Well Drilling"; 1921, Gulf Pub. Co. Suman, John R., "Petroleum Production Methods"; 1921, Gulf Publishing Company. Uren, Lester Charles, "Petroleum Production Engineering"; 1924, McGraw-Hill Publishing Company. Phelps, Robert William, and Lake, Francis Wilbur, "Petroleum Engineering"; 1924, Gulf Publishing Company. Herold, Stanley C., "Analytical Principles of the Production of Oil, Gas, and Water from Wells"; 1928, Stanford University Press. Cloud, Wilbur F., "Petroleum Production"; 1937, University of Oklahoma Press.

It was but natural that the geologist should be one of the first to understand and use the principles on which the early work in petroleum production engineering was based, since his conception of the reservoir was based on factual observations, and as a trained individual he also knew how to organize his facts. However, even though *many* geologists were endowed with some degree of engineering proficiency, the variety and complexities of the engineering problems with which they were confronted gradually led to the discrimination between geologic problems and production engineering problems. The zones of overlap which still exist between these two fields are steadily disappearing.

Recent Publications

Within the past two years excellent articles dealing with petroleum engineering education have been presented by Professor Plummer,* of the University of Texas, and by Stanley C. Herold,† so that little can be added by the writer.

Current Trends in Various Institutions

However, under the topic of Current Trends in Petroleum Engineering Education, an effort has been made to ascertain what such trends are by writing to the heads of the departments, or to the men giving courses in petroleum engineering and requesting their aid in the matter. The responses obtained have been most helpful, and the following quotations are taken directly from the letters of the various departmental representatives, unless the correspondence was loo long for quotation, in which case the general content has been digested and presented.

It is recognized that it is presumptuous to examine a college catalog, read the description of the courses, and then decide that one is familiar with the content of the courses described! Comparisons of the number of hours are even less satisfactory. This difficulty increases when it is necessary to compare institutions operating on a semester basis with those operating on a quarter basis. Attempts to reduce the credit hours of the latter schools by a factor of 2/3 have proved unfair in the case of certain types of courses, so that plan was not followed, and the credit hours shown are those established by the institution itself. A few cases were encountered where the hours are based on classroom, labora-

* Plummer, F. B., "Petroleum Engineering Education, Present Curricula and Future Possibilities," *Mining and Metallurgy*, October, 1936, Vol. 17, No. 358, page 485.

† Herold, Stanley C., "A Quarter Century of Progress in Petroleum Engineering Concepts," *Mining and Metallurgy*, December, 1937, Vol. 18, No. 372, pp. 554–56.

tory, and outside preparation, although that may be unjust in some respects. The Freshman year and field and summer courses have also been excluded unless the institution functions on an annual basis. In order to provide a more adequate basis for comparison in the summary the total credit hours have been placed at *one hundred per cent* and each subject then expressed as a per cent of the total.

Agricultural and Mechanical College of Oklahoma

The work in Petroleum Engineering at this institution is given as an option in Mechanical Engineering. These options start in the Junior year and continue through the last two years. At the present time courses in petroleum, chemistry, geology, petroleum production, petroleum refinery theory, and some elementary design are offered. There is no attempt made to specialize on any branch of the industry but to give a general knowledge of all phases of the field.

We have been considering adding two new courses to the curricula, one in petroleum development and the other a continuation of the refinery design work which will include more work on gasoline manufacture than is offered at the present time.

C. M. Leonard, *Associate Professor of Mechanical Engineering*

Agricultural and Mechanical College of Texas

We have been giving more mechanical engineering subjects and less geology in the last five years. We have also increased the amount of chemistry over and above what it was prior to that time.

In regard to the contents of our petroleum engineering courses themseves, we have added more material on production and measurement of natural gas and also more on production and drilling equipment.

Harold Vance, *Head, Petroleum Engineering Department*

Colorado School of Mines

At this institution there have been relatively few major changes in the past few years. We have always prescribed a preponderance of fundamental courses in mathematics, physics, chemistry and geology. Associated with those courses are thermodynamics, mechanical engineering courses, civil engineering and some electrical engineering. English, economics and related subjects are in about the same proportions as in other engineering schools.

We are avoiding, as much as possible, purely descriptive courses, in both this department and others. Our petroleum courses are usually given in the form of problem courses with as much description as is necessary for clarification.

If there has been any major change, it probably is in a more detailed study of principles and applications of fluid flow for production men. . . . Last year we put in a laboratory course which is chiefly concerned with

core analyses and fluid flow underground. The problem of reservoir energy is also being given more study, but this is merely the application of physics.

CLARK F. BARB, *Professor*

LOUISIANA STATE UNIVERSITY

The University of Louisiana has reduced the required geology from 34 credit hours to 30 credit hours. However, the course listed as "Petroleum Engineering, 0–104," in the senior year carries the title, "Sub-Surface Correlation," which makes it appear to be either a course in geology, or one very closely related to it. The two hours in chemistry are also optional with a course in map interpretation. Obviously in this curriculum, geology predominates at the expense of chemistry.

E. A. S.

THE MISSOURI SCHOOL OF MINES

In the Sophomore year the English course has been replaced by general engineering drawing; the electives in the Senior year first semester have been withdrawn to make a place for the English course formerly given to sophomores. Electives in the second semester of the Senior year have been replaced by land and topographic surveying.

E. A. S.

OHIO STATE UNIVERSITY

The Ohio State University began to offer investigation courses in petroleum production work during the fall of 1925. We had a formal petroleum option curriculum under the mine engineering department starting with the fall of 1927. This plan was followed for about four years; during the curtailment of appropriations in 1931 . . . we were forced to consolidate the petroleum option curricula with the mining engineering curricula. There was not a great deal of difference from the plan formerly followed except that some of the geology requirements were dropped.

We are now back again to a choice of petroleum or mining . . . in the third year the student can select chemistry or geology or accounting and business organization.

. . . we believe that if any extra time is added that the work will mainly be in non-engineering courses.

E. V. O'ROURKE, *Associate Professor, Department of Mine Engineering, Petroleum Division*

PENNSYLVANIA STATE COLLEGE

At this institution, petroleum engineering is taught with the idea of giving equal stress to the following aspects of the industry: petroleum production, natural gas production, and petroleum refining. It is not our purpose to try to make specialists out of our undergraduates; for instance to have them know the dimensions of oil field equipment, or the names of the different peculiar equipment which may be encountered in

actual practice, but we try to stress the fundamental principles on which the art of petroleum engineering is based. Accordingly we go very deeply into the following concepts: thermodynamics of flow of oil and gas mixtures in vertical pipes, theory of the flow of oil and gas mixtures through a porous medium (Jamin action, flow patterns according to the theories of Muskat and Wyckoff), design of gas lift equipment, counter-balancing of pumping wells and dynamometer card study, theory of secondary recovery methods, gas-oil ratio, bottom-hole pressure, study of free energy in bottom-hole samples, reserves in a field from bottom-hole data, reserves by decline curve methods, valuation, leases and royalties.

In the natural gas course, we stress particularly the methods of production, measuring, regulation, compression, distribution, and gasoline recovery, always from a fundamental point of view and explaining the principles rather than the actual equipment, although the student handles full size equipment in the laboratory.

SYLVAIN PIRSON, *Head, Department of Petroleum and Natural Gas Engineering*

STANFORD UNIVERSITY

. . . our petroleum engineering curriculum is a graduate one leading, in two years of graduate work, to the degree of Engineer; and presuming as preparation the substantial equivalent of the curriculum in general engineering offered by our School of Engineering.

The curriculum of the School of Engineering, in addition to its course requirements, provides for forty (40) quarter units in electives. Students preparing for graduate work in Petroleum Engineering are advised to make use of those forty units mainly in geology, chemistry, and physics courses.

The graduate curriculum in petroleum engineering has never been rigidly defined. It consists of at least forty-five (45) units taken within the Department of Mining Engineering, together with certain other science and engineering courses such as organic chemistry, physical chemistry, advanced geology and mineralogy, and engineering courses. The forty-five units taken within this department would mainly be courses in petroleum engineering and related subjects. Included in these is an allowance of from 5 to 10 units for a thesis. Both the graduate curriculum and the thesis are subject to the department in each individual case.

The tendency has been for the department to prefer that a student diversify his courses in the direction of fundamentals of science, engineering, and economics. It has been the view that the best preparation for the field of petroleum engineering is a thorough grounding in these fundamentals, rather than much specialization in the petroleum field at the expense of fundamentals.

. . . the courses have perhaps become less descriptive, with greater emphasis on the scientific aspects of certain practices and problems of the industry as, for example, the design, and beneficiation of circulating fluids.

FREDERICK G. TICKELL, *Executive Head, Department of Mining Engineering*

University of California

Under the heading of curriculum changes, we have eliminated a course in physical chemistry and added a course in thermodynamics in its stead, increasing the unit requirement from three to six. We have eliminated a course in tectonic geology, feeling that we were somewhat "top heavy" on the geological phase. We have added two units to our senior petroleum engineering course dealing with oil field development and petroleum production methods, increasing the unit requirement from four to six. We have eliminated the senior thesis as a common requirement, leaving it optional with the student whether he shall undertake a thesis or special elective courses in related subjects.

Our graduate seminar course has been altered somewhat. One-half of this course is now devoted to some phase of oil refining, whereas formerly both semesters were devoted to topics related to oil field practice or petroleum industry economics.

Lester C. Uren, *Professor of Petroleum Engineering*

University of Illinois

. . . the required courses as they differ from the standard mechanical engineering curriculum (are as follows): The first change occurs in the Sophomore year, when courses in engineering geology and historic geology are used as electives. Courses in plane and topographic surveying and in hydraulics are similarly elected in the Junior year. In the Senior year, three courses in applied petroleum geology are offered, one of them being a laboratory course, and two courses in petroleum production engineering problems—consisting primarily of the application of fundamental engineering theory to oil field development, production processes, recovery methods, storage, and transportation.

R. F. Larson, *Assistant Professor of Mechanical Engineering*

University of Kansas

The Department of Petroleum Engineering at the University of Kansas was established in the fall of 1937 and has followed the same general plan as that developed by the writer at the University of Missouri School of Mines and Metallurgy during the period from 1930–1937.

The underlying principle has been that a sound course in petroleum engineering must be based on fundamental sciences and mathematics; hence the first two years are given over almost entirely to basic subjects: chemistry, physics, mathematics and geology. Students are required to complete 10 hours of physics, 18 hours of mathematics, 18 hours of chemistry, and 10 hours of geology, before they are permitted to enter any of the specialized courses in petroleum engineering, which start in the Junior year.

The most important change has been the increased emphasis placed on applied mechanics, and the limitation of the course in physical chemistry to a single semester with five hours credit.

In the specialized petroleum engineering work, the natural gas course has been extended through two semesters and the time devoted to the design and layout of equipment has been doubled. The theoretical approach to oil and gas field problems predominates through all the courses, supplemented by the continual application of these principles to particular cases.

University of Oklahoma

During the first 9 or 10 years, we required 4 hours of civil engineering, 2 hours of alidade and 2 hours of mine survey. Mine survey was discontinued in 1935 and we now require 3 hours of general surveying. . . . Thermodynamics has been increased from 3 to 4 hours. Steam laboratory has been increased from one to 3 hours. Production men have always been required to take 5 hours of electrical engineering lecture and laboratory. Laboratory is one afternoon weekly, and deals with both alternating current and direct current. In 1933 a gas transmission and measurement course (3 hours) was introduced. It is required of students in petroleum engineering, mechanical engineering and natural gas engineering. A 3-hour course in economic geology has been discontinued. . . . Likewise, a 3-hour course in petroleum industry economics was dropped, primarily because it was taught in the school of business. We now require only 6 hours of economics; 3 hours of economic principles and 3 hours of accounting.

In 1935 we reduced the required hours to 143. The principal changes were:

Power plant design (3 hours) discontinued, substituting 2 hours of public speaking. Woodwork (one hour) was discontinued, substituting pipe line design (2 hours). Analytical geometry was reduced from 5 to 4 hours, mineralogy from 5 to 3 hours, applied mechanics from 5 to 4 hours, strength of materials from 5 to 4 hours, principles of economics from 5 to 3 hours. Surveying was cut from 4 to 3 hours, hydraulics reduced from 4 to 3 hours, and oil and gas geology reduced from 5 to 3 hours.

W. F. Cloud, *Professor of Petroleum Engineering*

University of Pittsburgh

First, we have added a course in secondary recovery, which is growing and will continue to grow in importance and application in the oil business. Second, we are improving the quality and increasing the amount of equipment in our natural gas and production laboratories so that the students may have better and more complete laboratory courses. Third, by various means throughout their last two years, we have attempted to impress the students with the fact that the oil and gas companies are in business to make money and not to produce as much oil and gas as possible; in other words, each problem with which they will be confronted is economic as well as technical.

G. L. Yates, *Instructor in Oil and Gas Production*

University of Southern California

The courses P.E. 101, P.E. 102, and P.E. 103 * have been rearranged and are now offered as a single year course, P.E. 101ab,† with an accompanying weekly field trip course, P.E. 102ab. The changes in the general content of the courses have been such as were necessary to keep the subject matter abreast of developments in the industry.

The petroleum technology course, "Chemistry 145L," has been revised and is now offered as "Chemistry 147L," 2 units, and the advanced quantitative analysis course, "Chemistry 115L," has been supplanted by a special analytical course for petroleum engineers, "Chemistry 14L." . . . You will also find certain changes have been made in the titles of some of the cultural courses, *i.e.*, "Psychology 51," "General Psychology," is now listed as "General Studies 51," "Problems of Human Behavior."

John F. Dodge, *Head, Petroleum Engineering*

University of Texas

We have raised the requirements for the first course in Petroleum Engineering to six credit hours in geology; more stress is laid on chemical training. We have also increased the laboratory hours devoted to the study of the flow of fluids through porous media and the efficiency of fluids in flushing oil sands. More trips to the field are also required.

Harry H. Power, *Head, Department of Petroleum Engineering*

University of Tulsa

(I) The petroleum production engineer might be compared with the mining engineer. He must have a thorough engineering training, yet it is important that he know sufficient geology to cope with the field problems encountered.

(II) The major change in the petroleum production engineering curricula at the University of Tulsa has been the reduction of the number of specialized courses in production and the addition of general engineering subjects and some geology. This has been due largely to the influence of industry to prevent specialization in undergraduate work.

(III) In the content of courses (production courses) less descriptive material, methods of drilling, pumping, etc., is being given and more problems are being given. It is felt that design of producing equipment and selection of material are more important to the student than methods which can be read about with no effort or study.

R. L. Langenheim, *Dean of Engineering*

Summary

From the evidence presented in these letters and from an examination of the curricula, it is apparent that petroleum engineer-

* Oil Field Development, Production of Oil, Storage and Transmission of Oil.

† Petroleum Production Industry.

SUMMARY SHOWING PER CENT OF TOTAL HOURS, SOPHOMORE TO JUNIOR YEARS INCLUSIVE, DEVOTED TO THE VARIOUS SUBJECTS IN THE INSTITUTIONS OFFERING COURSES IN PETROLEUM ENGINEERING

	Chem.	Refin. and Ch.E.	Engr. Dr.	Engr. Mech.	E.E.	Fuel Test.	Geol. and Miner.	Math.	Mech. and C.E.	Met.	Min.	Phys.	Pet. Engr.	Engl	Elec.	Misc.	Total Hours
A. and M. of Oklahoma	9.82	2.68	....	11.61	8.93	....	7.14	7.14	23.21	....	....	8.93	2.68	4.46	8.04	5.36	112
A. and M. of Texas	7.44	....	....	12.39	3.32	....	14.88	6.61	13.22	1.65	....	8.26	18.18	4.13	4.96	4.96	121
Colorado School of Mines	12.50	....	....	8.82	2.94	....	9.55	5.88	13.23	....	....	8.82	21.34	4.42	6.62	5.88	136
Louisiana State University	....	....	....	18.95	....	....	18.95	10.51	9.48	....	....	10.51	16.85	6.32	8.43 *or*	8.43	101
Missouri School of Mines	16.38	....	1.72	6.03	4.31	....	11.21	6.90	8.62	....	....	10.345	14.655	6.90	7.76	5.17	116
Ohio State University	....	....	1.81	9.70	4.85	....	14.55	6.06	4.85	13.33	23.03	9.09	3.64	....	9.09	....	165
Pennsylvania State College	12.73	3.63	....	7.275	7.275	2.73	10.00	5.45	6.36	1.82	....	9.10	20.90	1.82	10.91	....	110
University of California	6.00	....	....	12.00	3.00	....	21.00	6.00	9.00	2.00	6.00	6.00	20.00	....	9.00	....	100
University of Illinois	....	....	....	11.77	7.84	....	14.71	7.84	34.31	....	....	9.81	5.88	....	7.84	....	102
University of Kansas	13.89	....	....	11.11	2.78	....	13.89	7.41	8.33	....	....	9.26	17.59	4.63	5.555	5.555	108
University of Minnesota	1.78	1.18	....	11.24	....	....	25.44	5.33	2.37	4.73	15.38	8.88	18.94	....	4.73	....	169
University of Oklahoma	....	1.87	1.87	12.15	4.67	....	17.76	7.47	13.08	....	....	9.35	21.50	1.87	....	8.41	107
University of Pittsburgh	6.30	....	....	9.00	5.40	....	14.40	9.00	8.00	1.80	....	9.00	23.60	1.80	7.20	4.50	111
University of South. Calif.	4.85	....	....	11.65	5.83	....	15.53	5.83	5.83	....	....	8.74	12.62	1.94	10.68	16.50	103
University of Texas	12.00	....	....	9.00	....	....	12.00	6.00	13.00	....	....	12.00	21.00	6.00	3.00	6.00	100
University of Tulsa	11.88	15.84	....	8.91	5.94	....	5.94	5.94	6.93	....	....	11.88	12.87	1.98	....	11.885	101
MEAN (Total)	7.22	1.58	.337	10.73	4.19	.17	14.18	6.84	11.24	1.58	2.77	9.37	15.80	2.89	6.50	5.17	
MEAN (Participants)	9.63	5.04	1.80	10.73	5.16	2.73	14.18	6.84	11.24	4.22	14.80	9.37	15.80	3.855	7.42	7.51	

ing is rapidly passing from youth to maturity and cannot be regarded as a passing fad.

However, the summary shows that a few institutions still lack the comprehensive curriculum which is essential for the training of the production engineer. In most instances this statement applies to those institutions where the petroleum engineering is given as an option in some other department.

The researches of our industrial and educational laboratories have expanded our knowledge of the chemistry and physics of oil, gas, and oil-gas mixtures tremendously. Improvements in sampling procedures and in bottom-hole sampling equipment have made possible the diagnosis and duplication of reservoir conditions and thus stimulated further investigations of reservoir fluids and the experimental verification of theoretical deductions. Once the fluids have reached the well bore, the progress of the mixture can be predicted with reasonable accuracy, but only recently have we begun to grasp adequate concepts of the function of grain size, pore diameter, mineral composition, oil composition, gas composition, gas solubility, relation of volume changes to changes in the amount of dissolved gas, as well as to temperature and to pressure, surface tension, viscosity, permeability to gas, to oil and to their mixtures, effect of one fluid upon the behavior of its mixtures, etc., upon operating technique and ultimate recovery. The high temperatures and high pressures which prevail in the reservoirs of some of our deep fields demand the utmost skill and ingenuity on the part of the driller and the operator, who must depend for guidance on the production engineer. The latter in turn is confronted with the fact that he is dealing with a series of continual changes which must be kept under control at all times. Certain phases of chemical engineering, of hydrodynamics and thermodynamics become indispensable to him.

It seems to be generally recognized that training in fundamentals must continue to receive greater emphasis, if we expect the products of our petroleum engineering departments to meet successfully so many different kinds of problems. This means, then, that less stress shall be laid on the purely descriptive material and more on the theoretical, scientific base.

Engineering graduates become engineers, designers, executives, salesmen, etc., and as these grow in age, mellowness, and responsibility, they also acquire perspective. Usually these men have few regrets with reference to their collegiate training. Probably the most common complaint comes from the group which includes executives, and has to do with their lack of training in social science or the humanities! The group which includes those who have remained professional engineers, many of whom are also execu-

tives, usually reply, when asked to comment on desirable changes in their college training, "Stick to the fundamentals of science and mathematics. If they fail to acquire the fundamental theories and principles in college, they will probably never master them. The so-called *practical* changes from day to day, while the fundamentals merely expand; comprehensive training in these should produce men of the necessary breadth."

Some of the best supplementary courses now given in engineering schools carry the title of "the Dean's course." Here men with ample backgrounds of experience, and with wisdom acquired from a multiplicity of contacts with humanity have an excellent opportunity to inculcate the essential concepts of mutual responsibilities in human relationships. Such courses belong with the fundamentals and should be required of all engineers.

Regardless of formal curricula, the best teaching is dominantly inspirational and may well be described as that intangible part of personality which quickens the mind of impressionable youth and stimulates his latent desire to acquire knowledge, to do his work well and to carry his share of civic responsibilities.

UNDERGRADUATE THESES AS A MEANS OF DEVELOPING RESEARCH INITIATIVE AMONG FACULTY AND STUDENTS*

By E. R. DAWLEY

Professor of Applied Mechanics, Kansas State College

For several months the author endeavored to obtain the opinions of his colleagues on this subject. Nearly everyone consulted was definitely opposed to undergraduate theses. All of those personally consulted were teaching in a four-year engineering curriculum. Since the length of the college curriculum undoubtedly is a decisive factor in the use of undergraduate theses, the author has written the paper giving first, the views of those opposed to undergraduate theses, and later, the views of the proponents of undergraduate theses.

Common objections to undergraduate theses may be enumerated as follows:

(1) There is insufficient time for undergraduate theses under our present system of engineering education. Junior and senior schedules have only a few vacant hours a week. Faculty members frequently are unable to keep up with their technical reading to say nothing of improving themselves culturally.

(2) The trend in engineering education has been definitely away from undergraduate theses. A study of the catalogs readily available from 1911 to 1914 indicated that of 23 representative engineering schools undergraduate theses were required at 13 schools, were optional, or required with a five-year course, at seven schools, and were not required or not offered at three schools.

Undergraduate theses are now required at only two institutions and are optional to selected students, usually in connection with the five-year course, at five out of a representative group of twenty-three engineering schools. Undergraduate theses are not generally recommended even in the schools where they are permitted.

(3) The scientific value of unchecked calculations and conclusions of the average undergraduate student is nil.

In support of undergraduate theses it may be said that:

(1) An acceptable thesis must be fundamentally a coördination of individual course work.

* Presented at the Conference on Engineering Research at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

(2) The research aspects of an undergraduate thesis are largely self-motivating and such bait as cash awards, scholarship medals, membership in honorary societies, cut privileges, etc., are not required to keep the project moving. The investigator frequently goes into a one-man huddle and becomes oblivious of the passage of time.

(3) Undergraduate research may sometimes be used by faculty supervisors as material for technical papers.

The advantages of undergraduate theses are well illustrated by the following excerpt from a letter by S. R. Williams of Amherst College to a junior civil engineering student at Kansas State College:

I recall that about twelve or thirteen years ago the present President of Case School of Applied Science was here in Amherst studying the problem of why men do not go into engineering and why those who do take engineering courses do not stick by it but usually drift into managerial and other executive positions. He spent several days here studying the problem from the standpoint of the small college such as Amherst was at that time. I told President Wickenden at that time, and I still feel the same way, that the great difficulty has been in the type of training that engineering schools have been giving their students. There was a time when engineering was a fairly well cut and tried proposition, but as it seems to me now, that no longer exists. To teach a man to reach for his handbook to see how he should solve the problem is useless. When big manufacturing plants call in an engineer to solve their problems, the problems will be new, unheard of, and not to be found in the handbooks. The young engineer who doesn't know how to tackle a job of this sort at first hand, that is, as a research job, is simply lost. Give a man a training which teaches him to look upon every question which comes up as a research problem and you will find that man able to cope with any situation and if humanly possible he will be able to solve it. The illustration which I so frequently cite on this point is of a boy who did a nice little piece of research work with me about twenty-five years ago. It was published and every once in awhile I see it referred to. He left college and I didn't see him for ten years and then he dropped into my office on his return for the tenth reunion of his class. I said, "What are you doing?" and he replied, "I have hung out my shingle and am practicing marine law." To that I said, "I suppose you don't use much physics in that field." I shall never forget his answer, "No case comes into my office but what I attack it exactly as I did that little problem I did as a piece of research work in my senior year in college." You will see that I think of research work as one of the outstanding educative processes. It teaches men and women how to meet a problem first hand and solve it. We need men trained in that manner in all fields of knowledge. The process is not peculiar to any one field of human knowledge, but learned in one, is applicable in any other.

I feel that we are littering up our present curricula with too many formal courses in which we are trying to teach them how to use a microm-

eter, and that they could use their time to much better advantage if we should give them a real problem in which they would learn how to use the micrometer because they had to have it as a tool in solving the problem. In that way we could shorten our courses greatly or if not shorten them at least give a much more effective training. The recent developments in engineering schools like California Institute of Technology and Massachusetts Institute of Technology show that the engineers are realizing the values of research as a means of approach to a better understanding of the engineering problems.

The one difficulty in the way of putting this method into practice is the high ratio which still exists between the number of students and the number of teachers. The research method is distinctly an individual method of teaching. It can't be put through as a group process as we now do it. Each man or woman must be visualized as an individual. In the end, of course, that is the only way education should be carried on. To me it seems almost sheer nonsense to put all of our men through the same mill and expect to get good results. We put them through the same sausage mill and expect them to come out as links of wiener wurst, exactly alike, and usually they are wurst.

If you can do it, I should emphatically advise including research work and dropping some of the technical subjects. This is a method of learning to do by doing. By such a process I believe we could send our men and women out better equipped than they are now and not lengthen the time for doing it.

After thirty years' experience I am thoroughly sold on the idea that one of the most stimulating things which can happen to a teacher and a student is to start out on a coöperative basis to solve some problem which has come up in their work. Just now I am interested in the hardness of materials. I have a senior working on the hardness of glass and its allied physical properties. He has actually become excited over the problem and I know that I am getting a great kick out of this problem because we are going after it with a view that here is a puzzle that beats a crossword puzzle all hollow.

Dean R. A. Seaton of Kansas State College has made the following comments:

Theses were formerly required of all, or nearly all, seniors in engineering colleges. The primary purpose of this requirement was to develop the initiative and resourcefulness of the student and to give him some insight into research methods, rather than to develop new knowledge. To a considerable extent this primary purpose was accomplished and the thesis work was a valuable part of the training of the engineering student. However, as enrollments increased, the demands of thesis work upon the laboratory facilities and equipment became excessive and the instructors were unable to give the necessary amount of individual attention to students doing thesis work. This situation, and pressure for inclusion of additional courses in the curricula, led to the general abandonment of the senior thesis. More recently there has been a tendency toward the revival of the senior thesis in some engineering colleges, not as

a fixed requirement for all seniors, but as an option available to certain senior students who have special interest in, and ability for, such work.*

The trend away from undergraduate theses in the past twenty years does not indicate that they have lost their value but was caused, as Professor Williams and Dean Seaton said, by the greatly increased number of students per instructor. Increased space, facilities, and personnel in our engineering schools are obviously the proper means of overcoming this difficulty.

The University of Illinois has adopted, after some experimentation, a plan called the "Dual Curriculum" to give capable students who are interested a chance to do research work. A standard four or five-year course is offered and, in addition, a flexible curriculum for the student with an attitude of mind favorable to self-directed growth. After the first year, the student in the special curriculum follows an unwritten, flexible program of study more or less departmentalized in the last two years, but still flexible enough that it may be modified to fit the needs of the individual student. Only the more capable and intellectually mature students, chosen by a college committee, are admitted to the special curriculum. Each student in this curriculum is under the immediate attention of an interested faculty member who is responsible for his registration, scholastic, and professional guidance. Such a plan as this should lead to scholastic achievement of the right sort, but to quote Dean Enger who favors the plan very much, "Its operation depends upon the whole hearted coöperation of members of the faculty."

There are many questions and problems incident to the administration of undergraduate theses in existing curricula. What type of student shall be permitted to elect an undergraduate thesis? Where will he find time to do the work? Who shall supervise the research and what time can the instructor allot to supervision? These questions are real and they may be perplexing.

The unanimous answer to the first question seems to be that only the superior student who is mature enough to engage in self-directed work should be encouraged to undertake a thesis project. Some institutions rule he shall be scholastically in the upper ten per cent of his class. He may not be the type who would be classified by a personnel man as being best fitted for sales, operations, or service work.

An analysis of the time required of regular junior and senior engineering students at Kansas State College, in the class-room or laboratory plus the theoretical time required for preparation for theory courses (two hours preparation for each hour of recitation) indicated that the student may be required to work eight and

* R. A. Seaton, "Research in Engineering Colleges," JOURNAL OF ENGINEERING EDUCATION, Vol. 23, p. 67, October, 1932.

one-half to nine hours per day six days a week. Included in this time were four credit hours of elective subjects for the agricultural engineer, six hours for the architectural, chemical and civil engineers, and eight hours for the electrical and mechanical engineers. If the schedules were rearranged so that all of the hours of electives came in one semester then, in the case of the electrical and mechanical engineers, there would be available for research twenty-four clock-hours per week for one semester of eighteen weeks. In addition to this, if we limit research to those students in the upper ten per cent of the class, there will become available some nine to fifteen additional clock-hours per week, since this type of student does not require two hours preparation for each hour of recitation. This amount of time, together with several vacations each semester, should be sufficient for a modest research program.

Many students are irregular in their curriculum either because of taking part-time work in order to earn their expenses, or because of transferring a portion of their credits from some other school or curriculum. These students frequently have a final semester with little required work to finish and would, with a little faculty encouragement, elect thesis instead of the miscellaneous assortment of courses often selected to fill up the schedule.

The supervisor of undergraduate research should obviously be an intelligent, sympathetic, energetic, yet patient man whose knowledge in his field is broad and up to date. Among those ill suited to the supervision of undergraduate theses are the teachers who never have any home work, who spend every afternoon on the golf course, who stay at home every afternoon when they have no classes, who are seldom in town week ends; who play so much bridge or poker at night that they are unable to stay awake between classes; or who discourage student conferences such as a certain chemistry professor who, when a student appeared and asked a certain question, said, "I covered that point thoroughly in my lecture this morning and I don't propose to repeat it."

The average engineering instructor has little time for research work, either his own or his students'. A full teaching assignment in many colleges consists of sixteen hours of theory or twenty-one hours of laboratory instruction. With two hours of preparation, paper or report grading, student conferences, etc., for each credit hour, a forty-four hour week is usually too short, leaving no time for committee assignments, research, or professional advancement. Of course, the professor who has taught the same subject for a long time, from the same text book, may save himself some preparation time but he does so at the risk of going stale. It is obvious that the professor who is to supervise undergraduate theses must be relieved of a considerable amount of routine teach-

ing and committee work. Of course the teacher who intends to go ahead professionally is not interested in limiting his work to a forty-four hour week.

Conclusion

An undergraduate thesis, under proper conditions, affords a valuable means of stimulating and developing both the superior type of student and his faculty supervisor. By "proper conditions" is meant (1) that the student's curriculum has been arranged to provide time for research work and (2) that the faculty supervisor is enthusiastic about the research problem and has been relieved of some routine duties to provide the necessary time for the project. The selection of the project should, if possible, be voluntary both on the part of the student and his faculty supervisor.

CHEMICAL ENGINEERING FOR SENIORS*

By C. C. FURNAS

Associate Professor of Chemical Engineering, Yale University

The course for the senior chemical engineering students at Yale is built around the idea of handing out as little information as possible. The theory is that it is better to give the student some simple tools, direct him to the workings and let him dig up the nuggets of knowledge for himself, than to open a hopper of well assembled facts and let them pour into his head and out again.

In the process of digging the student learns two very important things: where to dig and how to dig. This we feel is far more important in the later stages of professional training than the mere acquisition of a host of facts or techniques. Handbooks, text-books and the periodicals are far better warehouses of technical information than students' heads. The student's cranium is porous at both ends. A great deal of extraneous material leaks in through the top and a large proportion of the technical material seeps out at the bottom.

We do not belittle the acquisition of technical information in the least but we do think that the undergraduate will eventually turn out to be a better engineer if emphasis is placed on facing a comprehensive problem, breaking it down into its logical parts, planning the attack and finally bringing into operation the technical knowledge which can be utilized in the solution. The technical knowledge comes last instead of first. We feel that the technical situations which we artificially create for the student's consideration, and often consternation, are very similar to those he will be called upon to meet if he is to be an engineer in the constructive sense of the word.

The Background

All of the work of the seniors in chemical engineering is centered around the solution of a series of comprehensive problems, made as real as possible. We operate on the assumption that the previous three years have been devoted to acquiring and sharpening a set of tools with which to work during the senior year. The student has had the conventional courses in general, analytical, physical and

* Paper presented at the Regional meeting of the S. P. E. E., Orono, Maine, October 8, 1938.

organic chemistry. His training in mathematics and physics has been of the ordinary variety. In his sophomore year he has been exposed to a course in elementary economics and has gotten his first contact with engineering affairs through a course in engineering mechanics. He does not come in contact with any strictly chemical engineering material until the junior year when he goes through a course of unit operations based on Badger and McCabe's "Elements of Chemical Engineering." This course emphasizes unit operation theory, descriptive material and problems. There is one semester of laboratory work which covers the simpler phases of unit operations with a certain amount of emphasis on development of manipulative skill. The student gets some experience here in making laboratory reports.

There are two courses during the senior year which we place in the category of background material. The first is one in chemical thermodynamics given by a member of the chemistry department. It is very thorough and fundamental and the cause of many a senior headache. The second is a one-semester course in electrical engineering which we consider a service course, designed to give a working and practical knowledge of electrical equipment as quickly as possible.

The Senior Course

During the September preceding the senior year the student takes a three-weeks laboratory course, in the unit operations and unit processes. He conducts experiments, closely similar to plant tests, on five different pieces of pilot-plant scale equipment; two full days to each test. He is given three additional days on a bona fide plant test on some part of the equipment of Connecticut Coke Company.

In the past year, each student had two-day experiments on five of the following ten pieces of equipment and processes:

1. Bubble cap fractionating column, separating alcohol and water.
2. Double effect evaporator, evaporating water.
3. Spray evaporator, evaporating water.
4. Ring-packed absorption tower, absorbing CO_2 in Na_2CO_3 solution.
5. Tray dryer, drying wall-board, sand and trays of water.
6. Twenty-five horsepower gas fired boiler.
7. Double pipe heat exchanger, heating lubricating oils with steam.
8. National Radiator Company Type B cooler sections, heating oil with steam, cooling it with water.
9. The manufacture of nitrobenzene, with subsequent counter current extraction of aniline from aniline water with the nitrobenzene.
10. The manufacture of aniline.

Two tests were run at the plant of the Connecticut Coke Company.

1. A complete heat and material balance on the boiler house using two 500-h.p. Stirling boilers evaporating a million pounds of water per day.

2. A heat and material balance on the light-oil recovery plant producing about 2,000 gallons of a mixture of benzol, toluol and xylol per day. The data were used to compute the individual coefficients of absorption of the benzol, toluol and xylol in wash oil in the absorbing tower. The class divided into two crews for the plant work making it possible to have 6-day tests.

This laboratory course is necessarily laid out with a number of exact directions because of the limited time for experimentation but the details of direction are kept to a minimum. Full and comprehensive reports are required on each experiment. The student is faced with the problem of making the apparatus work and he comes in contact with all the phases of innate cussedness of pilot-plant equipment.

With the above items in his background, or about to be placed there, the student is ushered into his senior chemical engineering work. This consists of four courses, which all look different in the catalog but which are planned as a roughly integrated whole and designed with one major objective in view,—to make the student scratch his head and then do something about it.

(1) *Chemical Engineering 44*

Principles of Chemical Engineering which may and does cover almost anything.

(2) *Chemical Engineering 48—Projects*

The student is assigned a small project, and told to carry it through from the flicker of the idea to the finished report, with adequate guidance, of course. Some of these assignments are research problems in the true sense of the word. Others cover old ground but to the student they are new and to him they are research. He must approach them with that attitude.

(3) *Chemical Engineering 46—Seminar*

The title is rather deluding, for the course is one in report writing, primarily reports on the Project. When the student finishes his year's work on his research he may not have much to report but the course is one that gives him training in saying that little well.

(4) *Chemical Engineering 42b—Plant Design*

This is a second semester course, with drawing boards, handbooks, slide rules, equipment catalogs and, we hope, a mind trained in the ways of attacking an engineering problem.

These various courses will now be discussed in a little more detail with most emphasis on the problem course; Principles of Chemical Engineering.

Principles of Chemical Engineering

There are no text assignments in this course, only problems. During the year 1937–38 there were eight of them. Most of them are comprehensive in the sense that they take in a large field, that is, the essential computations in the design of a plant or an important piece of equipment or some phase of operation of equipment. We try to touch on the essential points of the problem in hand without spending all the time on the calculation of minutiæ. We present the work in the form of broad and comprehensive problems, partly because it is much easier to hold the student's interest if he can see the whole structure, and partly because such an attack helps him to see the proper interrelation of parts.

The problems, in subject matter, do not differ materially from the problems usually given in conventional texts or in most classes, except perhaps in scope. The principal difference lies in the method of attack.

The year begins at the appointed hour and each student is handed a copy of problem number one and told to read it. Problem number one is short and looks quite innocent. It deals with the design of a piece of equipment to condense and cool a mixture of vapors of organic compounds and water (a bona fide problem by the way, taken almost verbatim from the files of a designer of heat transfer equipment). After the problem has been perused I call for comments. Occasionally, one of the brighter boys opines that that is easy, he'll take an hour off and do it that evening. Usually the response is: What *is* the problem, what do we do next? Then I inform them that that is the prime question of the entire year: What do we do next? The first thing an engineer must know is what to do, next how to do it. Heretofore, they have been told what to do and a great deal of how to do it. Now they are to decide for themselves what to do as well as how to do it. My function is to guide their reasoning through their field of work but they must get out their own tools and do their own digging.

The course is conducted on the assumption that the students know all they need to know about unit operations, chemistry, physics and mathematics. No book assignments are ever given; books

and periodicals are merely reference material. The only books required for the course are Badger and McCabe's "Elements of Chemical Engineering," Perry's Handbook of Chemical Engineering and a chemical handbook with Walker, Lewis, McAdams and Gilliland's "Principles of Chemical Engineering" and Groggins "Unit Processes in Organic Synthesis" as recommended material. Actually, of course, we recognize that they have not yet been exposed to enough of the background knowledge to solve the problems, so it is necessary to bring in lecture material on the advanced phases of unit operations, physical chemistry, differential equations, and thermodynamics as it is needed. Though the background material may wander down the side roads it is always related to the problem in hand. The students do not study distillation, evaporation, or absorption, they've already had those; they study the problem. If some part of the problem calls for something in distillation they have not had we talk about that, in the framework of the problem in hand. If they need more detailed technical information than I give them, they go to the handbook, or Chemical and Metallurgical Engineering or Industrial and Engineering Chemistry. At first I have to suggest where they should look. Before the year is over they know where to look.

From our point of view the ideal problem would be one in which no details were given and no method of attack indicated. We depart quite widely from that ideal in several cases by breaking up the main problem into several small ones. There are two practical reasons for doing this. First, we have found that if you give no indication of method of attack half the class flounders and gets nothing done. Eventually the poorer students pick up fragments of solutions from the better members of the class but that is hardly the proper way to give instruction. We find it a difficult task to give enough guidance but not too much.

The second reason for giving a partial break-down of the problem is for the saving of time. There *is* a great deal of technical material which is new to the student but which we want to bring in during the course of the year. We have found no one comprehensive problem which involves all the desired items. It requires several problems. Unless we limit the solution to certain specific parts they might spend most of the year on a single problem and we would not be able to build up as large a factual background as we would like. Problem 2, for instance, deals with a fermentation plant for making ethyl alcohol. If we simply stated the problem as being the determination of the size, character and method of operation of all the essential equipment of this plant, we would find that some of them would still be struggling with this one example until June. Unpleasant as a time budget may be, we find we have to use it.

Most of the problems have certain possibilities of use of judgment. There are assumptions which must be made. Hence, the answers of the different men will vary within certain limits. The students are given carte blanche and can make any assumptions they choose but they must stand ready to justify them. If methods of solution and answer show any great uniformity we know that there has been too much coöperation on the home work. It is necessary to change the problems to a certain extent each year.

The course is tailor-made, is cut over and, to a certain extent, re-fashioned every year. The students use their own data as much as possible. When a problem calls for the absorption of CO_2 in alkaline solution, they use the absorption coefficients which they determined on a pilot-plant column in their September laboratory course. They usually have to extrapolate to new flow conditions or other sizes of packing but that is simply part of their task. Sometimes, some of the data gathered from the plant test or from one of the individual projects can be fitted into the solutions. We patronize the home-made data as much as possible, not because it is better than handbook data, but because applying one's own data is one of the best motivating factors known. It makes this book-world seem much more real to the student.

Projects

The projects course deals largely in constructive discouragement. The student is assigned a problem with the warning that it's not as simple or easy as it looks. He never believes it. He soon finds, however, that he has no idea of how to start setting up apparatus and conducting a piece of research without printed directions. He flounders and usually becomes discouraged. It is the faculty adviser's job to keep the wheels turning. Eventually, the student gets under way and some of them turn in very creditable pieces of work by the end of the year. Occasionally, the results are good enough for publication, but not often.

The project titles show a great range in character. Here are a few typical ones.

(1) Determination of pressure drops in a stream of slurry flowings through a pipe.
(2) Absorptive capacity of activated alumina for water vapor.
(3) Overall absorption coefficients in a packed tower for the system CO_2-NH_3-Na_2-CO_3.
(4) Making of furfural from sugar-cane bagasse by means of superheated steam.
(5) The direct ethylation of benzene in a packed tower.

Despite the inevitable initial discouragement the better men in the class usually finish the year with a good deal of enthusiasm about their project. It is their first baby. The poorer men are seldom enthusiastic about anything, especially anything dealing with education.

As was mentioned above, the seminar, or report writing course is closely tied in with projects. Each student presents three written progress reports and two oral ones on his project during the course of the year. His written reports are carefully scrutinized and corrected and inevitably re-written. The oral reports receive constructive criticism on manner and method of presentation. The quality of both oral and written reports is judged on organization of ideas, logic, clarity of thought and form of presentation. The improvement in the reports during the course of the year is usually remarkable.

Plant Design

The climax of the year's book work comes with the Plant Design course in the second term. First, there is a small problem involving mechanical details to give the students the feel of the drawing board. The real work of the term is embodied in a single problem. Last year the problem was: Design a plant to produce 10,000 gallons of synthetic methanol per day. This was really a continuation of a problem in the course in Principles of Chemical Engineering. The bulk of the learning of the necessary fundamentals and the computation for many of the pieces of apparatus thus already taken care of. The design course centers around the selection of equipment, the plant layout and the integration of the parts into a reasonable composite.

The student synthesizes a geographical location and a logical terrain (hills, water courses, railroad sidings, etc.) and places and arranges his plant to fit in with his map. Finally, he makes cost estimates and presents a report on his work along with the finished drawings of layout and plant details. Obviously, he cannot design all the details in a one-term course but he usually covers a great deal of ground, and he is usually quite proud of his work.

Results

This type of course calls for a great deal of work on the part of the student—more on the part of the faculty. There can be nothing routine about it, for the problems keep changing. Every solution is different and the grading of papers and reports takes a long time. A great deal of individual supervision is necessary to lead the student to think things through. This calls for small classes and a relatively large instructional staff.

The poorer men tend to get unduly discouraged with the work, for mental initiative is something beyond their powers. They much prefer the text-book courses where there are definite small tasks, where they can see exactly what they are supposed to do. Frankly, a routine course might be better for these poorer men, for it is doubtful if they will ever be engineers in the constructive sense of the word. But we have embarked on the policy of designing the course for the better grade of men. We feel that it gives them an educational experience of lasting value. It does not injure the poorer men and it may do them some good.

PROGRAM OF S. P. E. E. HYDRAULICS CONFERENCE

Universty of Iowa, Iowa City, June 12–15, 1939

(Persons who wish to attend the Hydraulics Conference are requested to write to F. T. Mavis, Chairman, Engineering Building, Iowa City, Iowa. Further details are available on program, housing, recreation, entertainment, and points in Iowa of interest to hydraulic engineers who will drive to the Conference.)

Sunday, June 11, 1939 (afternoon and evening), Registration, Iowa Memorial Union.

Monday, June 12, 1939

Historical Development

9:00 Historical Development of Experimental Hydraulics. C. E. Bardsley, Professor of Hydraulics, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

10:00 Experimental and Practical Engineering Hydraulics of the Late 18th Century. J. J. Doland, Professor Civil Engineering, University of Illinois.

11:00 Hydraulic Model Testing in the Spotlight. Paul W. Thompson, 1st Lieut., Corps of Engineers, U. S. A., Director U. S. Waterways Experiment Station, Vicksburg, Mississippi.

12:00 Luncheon—Memorial Union.

Turbulence

1:30 Training the Student in Hydraulics. F. M. Dawson, Dean, College of Engineering and Director, Institute of Hydraulic Research, State University of Iowa.

2:30 Criteria for Similarity in Transportation of Sediment. Hunter Rouse, Associate Hydraulic Engineer, Soil Conservation Service, and Assistant Professor of Fluid Mechanics, California Institute of Technology, Pasadena, California.

3:30 Experimental Studies in Liquid Turbulence. A. A. Kalinske, Instructor in Hydraulics, State University of Iowa.

6:30 Dinner. 7:30 Tall Tales of the Mississippi River. William J. Petersen, Lecturer in Iowa History, State University of Iowa.

Tuesday, June 13, 1939

Hydrology

9:30 The Application of Hydrometeorology to Engineering Problems. Merrill Bernard, Chief, River and Flood Division, Weather Bureau, U. S. Department of Agriculture, Washington, D. C.

10:00 The Present Trend in Evaporation Experiments. Carl Rohwer, Irrigation Engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Fort Collins, Colorado.

11:00 Current Technique in Rainfall—Runoff Analysis. W. G. Hoyt, Hydraulic Engineer, U. S. Geological Survey, Washington, D. C.

12:00 Luncheon. (Informal groups.)

Models and Analogs

1:30 Dimensional Analysis. K. C. Reynolds, Associate Professor of Hydraulics, Massachusetts Institute of Technology, Cambridge, Massachusetts.

2:30 Use of Analogies in Fluid Mechanics. E. W. Lane, Professor of Hydraulic Engineering, and Associate Director in charge of the Laboratory, Institute of Hydraulic Research, State University of Iowa.

3:30 Demonstration of Fluid Mechanics Phenomena. R. A. Dodge, Associate Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Michigan.

6:30 Dinner. (Entertainment.)

Wednesday, June 14, 1939

Hydraulic Structures

9:00 Compilation of Reports on Hydraulic Model Studies. George E. Barnes, Head, Department of Civil Engineering, Case School of Applied Science, Cleveland, Ohio.

10:00 Spillways and Energy Dissipators. Jacob E. Warnock, Bureau of Reclamation, U. S. Department of the Interior, Denver, Colorado.

11:00 The Manifold Problem in Lock Design. Martin E. Nelson, Engineer, U. S. Engineers Department, and Associate Director, Institute of Hydraulic Research, Iowa City.

12:00 Luncheon. (Informal groups.)

Transportation of Silt and Detritus

1:30 Hydraulic Models—Geometrical or Distorted. Herbert D. Vogel, Captain, Corps of Engineers, U. S. A., The Engineer School, Fort Belvoir, Virginia.

2:30 Approaches to the Study of the Mechanics of Bed Movement. Lorenz G. Straub, Director, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, Minnesota.

3:30 Suspended Load Control and the Problem of Channel Stabilization. E. W. Lane, Professor of Hydraulic Engineering and Associate Director in charge of Laboratory, Institute of Hydraulic Research, State University of Iowa.

6:30 Dinner. 7:30 Looking Ahead in Hydraulics. J. C. Stevens, Consulting Engineer, Portland, Oregon.

Thursday, June 13, 1939

Open Channel Flow

9:00 Backwater Curves in Theory and Practice. C. J. Posey, Assistant Professor of Mechanics and Civil Engineering, State University of Iowa.

10:00 The Propagation of Waves in Prismatic Conduits. Harold A. Thomas, Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

11:00 Flood Forecasting in the Upper Mississippi Valley. Bertram S. Barnes, Hydrologic Supervisor, Upper Mississippi Region, Weather Bureau, U. S. Department of Agriculture, Iowa City.

12:00 Luncheon. (Informal groups.)

1:30 to 4:30 Round Table: *Instruments and Laboratory Materials.*

(1) Discharge Measurements and Flow Control.
(2) Measurement of Pressures and Velocities.
(3) Laboratory Materials and Model Kinks.

COLLEGE NOTES

Lehigh University.—The Board of Trustees named four new department heads, one of whom will serve additionally as dean of the College of Engineering; approved promotions for 14 teachers, and authorized two free scholarships for refugee students.

The new dean, effective September 1, will be Alfred C. Callen, head of the Department of Mining and Metallurgical Engineering at the University of Illinois. He will also become head of the Department of Mining Engineering.

Other appointees are Bradford Willard of the Pennsylvania Topographic and Geologic Survey, to become head of the Department of Geology; Gilbert E. Doan of the Lehigh faculty to become head of the Department of Metallurgical Engineering; and Allen J. Barthold of Yale University, to become head of the Department of Romance Languages.

Relinquishing their administrative duties under an age rule of the board, but continuing on the teaching faculty are Bradley Stoughton, dean of the College of Engineering, and head of the Department of Metallurgical Engineering; Benjamin L. Miller, head of the Department of Geology, and Howard Eckfeldt, head of the Department of Mining Engineering. Professor Bateman Edwards resigned as head of the Department of Romance Languages.

Promotions approved are: Robert D. Billinger to Associate Professor of Chemistry; Donald M. Fraser to Associate Professor of Geology; Thomas H. Hazlehurst to Associate Professor of Chemistry; Lawrence Whitcomb to Associate Professor of Geology; Cledo Brunetti to Assistant Professor of Electrical Engineering; Robert D. Butler to Assistant Professor of Geology; J. Calvin Callaghan to Assistant Professor of English in charge of speech and debating; Arthur T. Ippen to Assistant Professor of Civil Engineering; William L. Jenkins to Assistant Professor of Psychology; George L. Kehl to Assistant Professor of Metallurgical Engineering; Arthur E. Pitcher to Assistant Professor of Mathematics; John G. Roberts to Assistant Professor of Romance Languages; Raymond F. Schultz to Assistant Professor of Chemistry; Hilton A. Smith to Assistant Professor of Chemistry.

New York University.—Many developments have occurred recently in Rotary Wing Aircraft, both in the autogiro and helicopter fields. The Focke helicopter in Germany has particularly shown amazing qualities. These achievements in Rotary Aircraft

together with the Dorsey Bill, authorizing a sum of two million dollars for Rotary Aircraft to be expended under the supervision of the Army Air Corps, have induced great interest in this new field of Aeronautical Engineering.

At the Daniel Guggenheim School of Aeronautics, College of Engineering, New York University, continuous attention has been given to Rotary Aircraft since 1924, by theoretical and experimental research, student theses, and staff publications. The School of Aeronautics is now offering a new curriculum in Rotary Aircraft which is probably the first of its kind offered anywhere in the world. This will include Aerodynamics and Structural Theory of Rotary Aircraft; Advanced Machine Design with special reference to the transmission elements of the helicopter and autogiro; Rotary Aircraft Design; Research in Rotary Aircraft and selection of general courses in Applied Mathematics, Theory of Elasticity, Dynamics of Aircraft and Mathematical Theory of Vibration.

The curriculum will be in the graduate division of the College of Engineering and will lead to the degree of Master of Aeronautical Engineering.

Under the auspices of a distinguished group of men interested in the advancement of Rotary Aircraft there has also been established a Cierva Memorial Fellowship for the furtherance of fundamental research. The Fellow will be selected from graduates in Aeronautical or Mathematical Physics of recognized universities and technical schools. He will be appointed for one year and probably re-appointed for a second year. A substantial stipend for the Fellow and funds for such apparatus will be available. Applications for this fellowship are now being considered.

NECROLOGY

HENRY BISSELL ALVORD, Chairman of the Department of Civil Engineering at Northeastern University, passed away after a brief illness on Thursday, April 20, 1939, at the age of fifty-three. A graduate of the Massachusetts Institute of Technology in the Class of 1907, he served the Institute as an Assistant in the Department of Civil Engineering until 1910. From 1910 to 1914 he held an Assistant Professorship in Civil Engineering at Bowdoin College. In 1914 he left teaching temporarily to accept an engineering position with the Aberthaw Construction Company of Boston by whom he was employed for four years. At the end of this period he returned to the field of teaching at Wentworth Institute in Boston for the school year 1919–1920.

Coming to Northeastern in September 1920 as Assistant Professor of Civil Engineering, Mr. Alvord was promoted to Professor of Civil Engineering and Chairman of the Department in 1921, a position he filled from that time until his death.

In addition to being active in the S. P. E. E., Professor Alvord found time to carry on many professional activities. He served at one time as consulting engineer for the City of North Adams, and later as director of the triangulation survey of the Cascade Tunnel for the Washington and Great Northern Railroad. Professor Alvord was a member of the American Society of Civil Engineers and of the Boston Society of Civil Engineers. He was past librarian and a member of the Board of Directors of the latter society at the time of his death.

Professor Alvord had long been interested in the Massachusetts Federation of Planning Boards of which he was the treasurer. In his home city of Melrose, he was active in musical circles, particularly in the Beethoven Club.

At Northeastern University Professor Alvord taught courses in structures, concrete, and highways. He was always interested in the college life of his students and was active on the tennis courts up until the year of his death. Each year he took pleasure in planning a number of inspection trips and excursions which combined technical interest with opportunity for social intercourse among faculty and students. His quiet, friendly personality will be greatly missed from the Northeastern campus.

CHARLES SUMNER HOWE, a past-President of the Society for the Promotion of Engineering Education, died on April 18, 1939, at his home in North Amherst, Massachusetts, at the age of 80.

Dr. Howe was born in Nashua, New Hampshire, September 29, 1858. After study at Massachusetts State College, leading to the degree of B.S. in 1878, followed by a year of advanced study in

Mathematics and Physics, he served for a brief period as Principal of the Longmeadow, Mass., High School, and for two years as Principal of Albuquerque Academy in the then frontier territory of New Mexico. Graduate work in Mathematics and Physics at Johns Hopkins occupied the year 1882–1883.

In September 1883 he accepted appointment as Adjunct Professor of Mathematics and Astronomy at Buchtel College, Akron, Ohio and the following year was advanced to the rank of Professor. At once his power of precise analysis and lucid exposition began to be felt. Dr. Howe served at Buchtel until 1889 when he was called to the chair of Mathematics and Astronomy at Case School of Applied Science.

His leadership at Case was outstanding. On the retirement of President Cady Staley in 1892, Dr. Howe was chosen as temporary head of the Faculty, and at the end of one year was appointed President. His twenty-seven years of service in this capacity were notable in the upbuilding of the institution in physical plant, in endowment, and in educational standards. His civic responsibilities were numerous. These included a term as President of the Cleveland Chamber of Commerce which later made him an honorary member and in 1927 awarded him its medal for distinguished public service. He also led a citizens' committee which was instrumental in bringing about the establishment of East Technical High School.

Dr. Howe became a member of the Society for the Promotion of Engineering Education in 1902 and was elected President at the Cleveland meeting in 1907. He also served as President of the national Society of the Sigma Xi and the Cleveland Engineering Society. He was a Fellow of the American Association for the Advancement of Science and of the Royal Astronomical Society. Dr. Howe was awarded honorary degrees by the College of Wooster, Mount Union, Oberlin, Armour Institute, Western Reserve University and Case.

In a tribute to Dr. Howe at his funeral in Cleveland on April 21, 1939, his successor, President Wickenden, summed up his character and service in these words:

> For twenty-seven years he continued to stamp his character ever more deeply on Case School. Its standards were shaped more and more to his standards, its ideals to his ideals, its spirit to his spirit. A firm believer in discipline, a man of just and even judgment, a lover of excellence, a believer in things tried and true, a man dominated by the compulsions of loyalty and duty, he molded the college in his own image. Case came to be known everywhere as an institution of permanence and stability, to which men formed lasting attachments. There could never be anything shoddy about it. Its aims were solid and not ephemeral. The institution was but the lengthened shadow of its leader, Charles Sumner Howe.

HERMAN SCHNEIDER, Dean of the College of Engineering and Commerce of the University of Cincinnati, died on March 28, following a brief illness. His death came at a high tide in the educational and scientific activity for which he was noted. For some months he had been working with a committee of the Faculty on a program to heighten the effectiveness of the coöperative course. At the same time he was giving close attention to the course of study in the School of Applied Arts, of which he was Director, and to the Institute of Scientific Research, whose basic science laboratory he had directed since it was founded by him in 1920. One of his latest activities was to serve as consultant to the Walter P. Murphy Foundation in organizing the new Institute of Technology at Northwestern University.

The circumstances of Dean Schneider's own student life pointed logically to the contribution which he was destined to make to engineering education. Throughout his stay at Lehigh University, from which he was graduated in 1894 with the degree of Bachelor of Science in Architecture, he worked in an architect's office after class hours and in vacation periods. This combination of study and training prepared him for the practice of architecture, which he followed from November, 1894, to September, 1899, the date of his appointment as instructor in Civil Engineering at Lehigh University.

During a career of nearly forty years as an educator, Dean Schneider held to the belief that in technological training the student would profit by obtaining his demonstration of theory in the laboratory of industry. He developed a practical plan for doing this and persuaded a university and a number of industrial concerns to try it. This working arrangement between college and industry, which he inaugurated in 1906 at the University of Cincinnati, was known as the "coöperative" system of education.

Every one is familiar with the subsequent extension of the cooperative principle to different branches of engineering and to other kinds of training, such as commerce and applied arts, and to various colleges in the United States and abroad. As director in his own college and as consultant elsewhere, Dean Schneider was constantly occupied with detail problems in the development of the coöperative idea. Other aspects of education which came under his direction included such diverse activities as public school advisory work for the Committee on School Inquiry of the City of New York, war service on the Committee on Education and Special Training of the United States General Staff, and a period as President of the University of Cincinnati between 1928 and 1932.

The concept of coöperative education presupposed a close familiarity with the problems of industry as well as with the training

value of industrial processes and equipment. In his relations with industry Dean Schneider was not concerned with specific or "shop" matters, but with broad aspects of science, economics, and even public policy. The Resource Survey which he conducted for the Cincinnati Commercial Club cited all industries which might be located in a given area but emphasized those which should be encouraged as a matter of sound community development. He persuaded such organizations as the Tanners' Council and the Lithographic Research Foundation to omit detail manufacturing problems and to concentrate upon basic fundamental research. It was with this understanding that they became participating members of the Institute of Scientific Research. In the same way, his contribution to management in industry took the form of analytical studies of the nature of work and of the psychological laws affecting the worker. His record for fairness as an arbiter in settling industrial disputes gave weight to his writings in the field of what might be called "human engineering."

Inevitably Dean Schneider's contacts with industrial leaders and affairs reacted upon his educational philosophy and helped to shape the coöperative course under his direction. To preserve some of the results of his observation over the years, he had planned several books of essays. The first of these, "The Problem of Vocational Guidance," was published in 1937. This brief volume illustrates his trenchant style of writing as well as his ripe experience. Other parts of the record must be pieced together from his many short articles and from scattered accounts of his active life.

SECTIONS AND BRANCHES

Case Branch.—At the dinner meeting held in December, the thirteen new instructors on the Case faculty were welcomed to the branch. Current issues of the JOURNAL were distributed to them, and they were urged to become active members of the branch, and join the national organization.

President W. E. Wickenden gave a talk on the history and progress of the S. P. E. E. from its inception to the present. The second speaker was Walter Beam, Executive Vice-President of the Cleveland Chamber of Commerce. Mr. Beam's talk was on "The Extent to which Business Administration Subjects should be Included in an Engineering Curriculum." Mr. Beam, himself an engineer and Industrial Management Consultant, was well qualified to present the subject and lead the lively discussion which followed.

The Executive Committee of the Society has just approved the establishment of the **Colorado State College Branch** of the Society with the following officers:

Chairman, Fred B. Beatty,
Secretary, Dwight Gunder.

At the meeting of the **Michigan Section,** held at Wayne University April 29, 1939, the following officers were elected:
Chairman—E. L. Ericksen, University of Michigan.
Vice-Chairman—L. G. Miller, Michigan State College.
Secretary-Treasurer—R. A. White, Grand Rapids Junior College.

The Eighth Annual Meeting of the **Missouri Section** was held at Washington University, St. Louis, on April 21–22. There were 76 persons present. Chancellor George R. Throop, of Washington University, made a short speech of welcome, and Dean A. S. Langsdorf, of Washington University, spoke in behalf of the Engineering School. The guest speaker Friday evening was C. W. Rippie, Technical Salesman of The Solvay Company, who spoke on the subject of "Education; Engineering Students." His talk covered in a detailed manner the continuing of the education of the engineer after he gets into industry. After the addresses of welcome and before Dr. Rippie's talk the ladies adjourned to Brown Hall on the Washington University Campus to be entertained under the direction of Mrs. A. S. Langsdorf. The guest entertainers of that

program were Mrs. Francis O. Schmidt, pianist, and Mrs. Gustave Goetsch, artist lecturer. The men joined the ladies after Dr. Rippie's talk.

On Saturday, April 22, the following conferences were held:

Chemical Engineering, Frank H. Conrad, Chairman.
Discussion on "Design Courses in Chemical Engineering."
Electrical Engineering, Clifford M. Wallis, Chairman.
Mechanical Engineering, R. E. Jackson, Chairman.
Civil Engineering, E. W. Carlton, Chairman.
"Stimulating Enrollment in Civil Engineering."
English, Alex. Buchan, Chairman.
"How Much Literature does an Engineering Student Need?"
Mathematics, Ross R. Middlemiss, Chairman.
Professor Bubb: The Photo Analysis of the Roller Bearing.
Professor Grummann: The Correction Factor for the Velocity Term in Bernoulli's Equation for Turbulent Flow in Circular Pipes.
Physics, John M. Willson, Chairman.
Round Table Discussions on the tentative subjects:

1. What should be the relation of physics to engineering and of engineering to physics as taught in the engineering school?
2. In what ways, if any, should the course in physics for engineering students differ from the course offered for the student of arts and sciences?
3. What aspects of the modern physics have a definite place in the course in physics offered for engineers? (Dr. Hughes will lead.)
4. Should a "degree curriculum in Engineering Physics" be offered? (Dr. Varney will lead.)

The following group chairmen were selected for the year 1939–40:

Chemical Engineering—Jules Bebie, Consulting Chemical Engineer, St. Louis, Mo.
Electrical Engineering—P. Ranes, Rolla School of Mines, Rolla, Mo.
Mechanical Engineering—R. O. Jackson, Mo. School of Mines, Rolla, Mo.
Civil Engineering—Harry Rubey, University of Missouri, Columbia, Mo.
English—J. W. Barley, Rolla, Mo.
Mathematics—none selected.
Physics—none selected.

The general session met in Crow Hall at 11 A.M. Reports were presented by the group chairmen. The following new officers for

the coming year were elected unanimously upon nomination by the nominating committee:

Chairman: Harry A. Curtis, University of Missouri.
Vice-Chairman: R. S. Glasgow, Washington University.
Secretary: F. H. Frame, Missouri School of Mines.

The Resolutions Committee brought in a set of resolutions of thanks to the hosts of the meetings, which was unanimously adopted.

W. W. Horner, of the Civil Engineering Department of Washington University, gave a half-hour talk on the subject "The Engineer in Government." Inasmuch as Professor Horner has had many years experience in government engineering work around St. Louis, the Secretary recommends that a complete copy of this talk be requested of Professor Horner to be sent to the editors of the JOURNAL for publication. The Secretary feels that it would be completely inadequate to abstract this important paper here.

EUGENE STEPHENS,
Secretary.

NEW MEMBERS

AYRE, ROBERT S., Instructor in Civil Engineering, Oregon State College, Corvallis, Ore. C. A. Mockmore, F. Merryfield.

BARTON, MILLARD V., Instructor in Machine Design, Cornell University, Ithaca, N. Y. C. D. Albert, P. H. Blank.

BENEDICT, R. RALPH, Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. B. G. Elliott, J. R. Price.

BENNETT, EARL F., Instructor in Civil Engineering, University of Maine, Orono, Me. Paul Cloke, W. S. Evans.

BOCKHORST, ROLAND W., Instructor in Applied Mathematics, Washington University, St. Louis, Mo. Eugene Stephens, A. S. Langsdorf.

CHILTON, THOMAS H., Director, Technical Division, Engineering Dept., E. I. duPont de Nemours & Co., Wilmington, Del. R. C. Kintner, H. McCormick.

CLANTON, JACK R., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. A. Diefendorf, W. Irwin Short.

COOK, WARREN S., Designer, Bridge Dept., Iowa Highway Commission, 1121 Harding Ave., Ames, Iowa. T. C. Shedd, Frank Kerekes.

DE GARMO, E. PAUL, Instructor in Mechanical Engineering, University of California, Berkeley, Calif. B. M. Woods, H. B. Langille.

DOWNS, WILLIAM S., Professor of Railway Highway Engineering, West Virginia University, Morgantown, W. Va. G. P. Boomsliter, R. P. Davis.

GRAY, TRUMAN S., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, E. L. Moreland.

HEDENBERG, NORMAN A., Teacher of Mathematics, Wilbur Wright Junior College, Chicago, Ill. Wm. G. Smith, G. A. Maney.

HENRY, GEORGE F., Associate Professor of Mechanical Engineering, Colorado State College, Ft. Collins, Colo. F. B. Beatty, J. T. Strate.

KILLIAN, JAMES R., JR., Executive Assistant to the President, Massachusetts Institute of Technology, Cambridge, Mass. Karl T. Compton, E. L. Moreland.

LEASE, L. J., Associate Professor of Mechanical Engineering, Industrial Coordinator, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, J. J. Schommer.

LEWIS, ROBERT L., Assistant Professor of Civil Engineering Colorado State College, Ft. Collins, Colo. N. A. Christensen, F. B. Beatty.

LEWIS, WILLIAM A., JR., Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y. F. J. Bristol, W. E. Meserve.

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MCGRADY, DENTON D., Instructor in Chemical Engineering, Michigan State College, East Lansing, Mich. H. E. Publow, M. G. Larian.

MOYNIHAN, JOHN R., Assistant Professor of Experimental Mechanical Engineering, Cornell University, Ithaca, N. Y. J. R. Bangs, G. R. Hanselman.

PENNOCK, OLIVER P., Associate Professor of Civil Engineering, Colorado State College, Ft. Collins, Colo. N. A. Christensen, F. B. Beatty.

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ROOS, PHILIP K., Instructor in Civil Engineering, Undergraduate Center, Pennsylvania State College at DuBois, Pa. L. A. Doggett, J. M. Holme.

SAGER, EDWIN H., Instructor in Mechanical Engineering, Washington University, St. Louis, Mo. Eugene Stephens, A. S. Langsdorf.

SIMPSON, WILLIAM M., Instructor in Civil Engineering Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, L. E. Grinter.

STRALEY, HARRISON W., Instructor in Geology, University of North Carolina, Chapel Hill, N. C. C. R. Bramer, A. T. Greaves-Walker.

WANDMACHER, CORNELIUS, Instructor in Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. L. F. Rader, E. J. Squire.

WILSEY, EDWARD F., Associate Professor of Civil Engineering, Ohio University, Athens, Ohio. E. H. Gaylord, N. D. Thomas.

BOOK REVIEWS

Estimates and Costs of Construction. F. W. STUBBS, JR. John Wiley and Sons, Inc., New York, 1938. x, 234 pp. $3.00.

This book is written as a suitable text-book for a two- or three-hour course in the construction field. The book has been written primarily for student use but could be profitably read by constructors, engineers and architects.

The author has written a text on a subject too generally neglected in many engineering curricula. The engineer is too generally criticized for his lack of economic perspective in his design, and the contractor too often has not used logic in preparing his cost estimates; for this reason a study of this book would prove profitable.

He has covered a brief history of the construction industry, a discussion on approximate estimating methods, detailed estimates, comparable studies of Contract vs. Day-Labor, cost keeping and depreciation items.

A. DIEFENDORF

101 Problems in Drawing Board Geometry. FREDERIC G. HIGBEE, SR., M.E., Professor and Head of the Department of Engineering Drawing, The University of Iowa. Published by John Wiley and Sons, Inc., 1938.

101 Problems in Drawing Board Geometry. The sheets 7¾ by 10½ inside the border are of good surface white drawing paper. The sheets are punched to fit a three-ring cover when removed from book.

From the author's Introduction, Drawing Board Geometry is but one of the modern names for descriptive Geometry. Two hours should be allowed for the solution of each problem. The problems are designed to be worked under supervision of instructor. Problems may be solved by methods and principles of descriptive geometry; also the arrangement of the graphical data has been planned to encourage the use of the auxiliary plane method.

Solutions will be contained entirely on the sheet. No bizare or trick problems have been included.

Several of the problems, picked at random, follow:

Problem 12. *O* is the outlet to a flume running N. 75° 00′ E. for 293.0 feet on a rising 12% grade. The contract price per foot is $6.47. Make drawing of the flume and compute its cost. Scale 1″ = 50′. Use sheet 392–2.

Problem 60. Complete the plan and elevation of the factory building and draw a complete left end view. State the true size of the valley angle between the two roof sections and the true slope of each roof. Scale 1″ = 24′. Use sheet 3812–1.

The above are mentioned not as the best illustrations of problems, but because the problems are practical in nature while illustrating principles of Descriptive Geometry.

W. Irvin Short

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

F. M. PORTER, *Editor*, University of Illinois

"SOMETHING TO THINK ABOUT IN THE TEACHING OF DESCRIPTIVE GEOMETRY"

"If present weaknesses of Civil Engineering education are to be corrected, we must look for higher efficiency through the elimination of wastes. The teaching of useless or idle subjects should be eliminated. Such unenlightening disciplines as Descriptive Geometry are outworn and should at once be discarded."

The above statement was recently made at a Civil Engineering conference in New York. Similar remarks are sometimes made by practicing engineers and draftsmen. I believe they are occasioned by the observation of the results of the wrong kind of teaching of Descriptive Geometry and consequent failure to arouse the interest of the student in its possibilities. Interest in Descriptive Geometry can be stimulated only if there is understanding and appreciation of the practical values and objectives of the course.

The primary objective of Descriptive Geometry is to teach the student to read and write the graphical language in a clear, concise, and complete manner. The necessary training to accomplish this objective is an asset to the student, and unless the instructor permeates his lectures with practical applications of Descriptive Geometry by means of illustrations or examples, then the student's response will be negligible, because of a lack of interest due to his inability to understand the practical use of the subject he is trying to assimilate.

Interest can be stimulated by bringing into the drafting rooms carefully selected drawings of existing machines or structures which show the application of Descriptive Geometry. These examples create a desire in the student to improve his work. In addition to noticing the practical applications, he will also notice lettering, contrast in lines, dimensioning, etc. He will derive a great deal of satisfaction in knowing that he is able to read and understand the displayed drawing, and begins to realize that he must achieve that standard if he desires to begin his profession as an engineer.

Another practical aspect, very seldom emphasized, is the use of Descriptive Geometry for graphical computations. For example, solving for the true lengths of lines, sizes of angles and planes, and perpendicular distances between lines are only a few examples of problems which can be solved much more rapidly by means of Descriptive Geometry than by mathematical computations. The results obtained are of sufficient accuracy for all practical purposes, and very often the auxiliary and oblique views are necessary parts of the working drawing.

Again, interest may be created by taking the class on an inspection tour of the engineering laboratories so that they may see structures which are in oblique positions, shafts with intersecting center lines, transition pieces, pipe bends, and elbows, and other examples which illustrate the many applications of Descriptive Geometry. Advanced drawing courses should include problems in which the student must determine the geometric relations of the elements which make up the structure before legible working drawings can be made.

Since the quickest way of getting information into our mind is through the eyes, the little time spent in showing the student these practical applications will do much to impress him with the necessity of a good knowledge of the theory of drawing.

JASPER GERARDI,
Assistant Professor of Drawing,
University of Detroit

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.—Editor, M. W. FURR, *Kansas State, Manhattan*

F. T. MAVIS, *Chairman*
H. C. BIRD, *Past Chairman*
F. W. STUBBS, JR., *Secretary*
M. W. FURR, *Editor*
H. T. HEALD
PAUL P. RICE
HALE SUTHERLAND

DIRECT TECHNIQUES FOR DEVELOPING SPECIFIC CIVIL ENGINEERING SKILLS*

BY H. S. CARTER

Professor of Civil Engineering, Utah State Agricultural College

The development of professional attitude in students seems to be one of the major objectives or the ultimate objective of every engineering teacher. Professional attitude is herein understood to be the manner in which mature engineering minds view the present and future of engineering as it effects the economy, convenience, and comforts of society through ever improved methods of production, transportation, communication, public health, happiness, and safety.

Fundamental to the development of professional attitude appears the necessity of inducing students to LIVE acts that are performed by engineers in the field or office, whether surveying, designing, testing, inspecting, constructing, or supervising. When students can visualize themselves doing these things, and can see benefits accruing to the community, state, or nation from such acts, they may be considered as potential engineers of first order. Emphasis is here placed on the importance of each student being motivated to live the acts performed. This seems to be an accepted axiom which stated in other words: "To learn a thing it is necessary to live that thing either through mental activity or through a combination of mental and physical activity." The purpose of this paper is to discuss the question of "How" to get students to "Live" engineering acts whereby they may develop that professional attitude which is fundamental to the greatest success in the field of civil engineering or in any field of engineering.

Professional attitude, wherever found, seems to be contagious. If this is true, then those instructors who live and radiate professional attitude in and out of the classroom have at work a most effective direct technique for the development of civil engineering skills. Professional attitude as applied to specific engineering problems includes that mental approach which seeks "the best design," "the right method" or "the whole truth." Diligent search for the most logical solution to an engineering problem seems to create in students the desire and ambition to be first rank engineers. In the classroom

* Paper presented at meeting of the C. E. Division, 46th annual meeting S. P. E. E., A. & M. College of Texas, June 27–30, 1938. (Abstracted by Editor.)

search for the right answer, correct solution or best design, those students who contribute basic ideas to the solution of the problem may be given classroom recognition to advantage. Credit thus given tends to create professional enthusiasm and to encourage serious original thinking. . . .

Where a series of formulas are to be mastered, a means of motivation may be secured by assigning one or two students to be especially prepared to demonstrate to the class a specific formula and to suggest one or more direct applications wherein the respective formula has use in practice. Each student, under this method of teaching, is also required to study all formulas to be discussed. This plan of teaching insures that each student in the class will have a thorough understanding of one important part of the assignment and a general understanding of the whole assignment when the class work begins, and is thereby better able to understand and follow other student derivations. This practice also helps students to organize their processes of thinking which develops capacity for rapid accurate work, a trait that is especially valuable to the engineer.

Reading courses such as city planning, contracts and specifications, or economics, where classes are small, may be conducted, wholly or in part, as a seminar course. Seminar procedure provides a means of covering two or three times the subject material normally studied and at the same time the students have the benefit of personal organization and presentation of the material. Periodic review discussions directed by the instruction insure emphasis on the salient points and different angles covered by student presentations.

Students held responsible for performing certain well defined duties and subsequently required to instruct another student in the performance of the same duties seem to grasp the engineering technique involved much more readily than otherwise. Instruction of this nature is possible in many testing or surveying laboratory problems where party positions are rotated or where problems are performed by respective parties in sequence. A modified form of this practice is commonly used wherein students are required to familiarize themselves with the problem procedure from instruction sheets sufficiently to outline to the instructor the procedure and steps to be followed. Student understanding of the value and purpose of the problem to be worked is quite essential to rapid assimilation of the salient points of the problem. Thus the purpose of a polaris reading may be to establish the true bearing of a new base line for a campus control survey.

Laboratory supervised study is a generally accepted effective method of teaching students engineering skills. This method of teaching is recommended where the schedule and teaching loads permit. The details of this method are quite standard and will not be treated in this paper. . . .

Visual instruction through slides, opaque pictures, and movies, with or without talkies, seem to be universally used to good effect and do have a definite place in the development of engineering skills. An illustrated lecture is somewhat similar to a map in that the whole is generally reduced to a form that permits a more rapid comprehensive grasp of the field under study.

Models and blackboard sketches provide tangible means for students to get a more rapid grasp on the skills of engineering and may be considered forms of visual education which make for more rapid assimilation of data from which deductive or inductive reasoning is the logical result. The accelerated rate of learning necessary for students to assimilate a reasonable amount of the knowledge placed before them during the four years of their college life seems to justify every means of simplification of teaching methods which will encourage and increase organized clear rapid thinking on the part of students.

Laboratory or field demonstrations by the instructor of correct procedure in the handling of equipment or in the manipulation of material tends to instill confidence in students. Such demonstrations followed by student repetition of the same steps seem to accelerate the acquirement of professional skills. . . .

There are several other methods whereby civil engineering teachers may develop "the professional side and understanding" and "the specific civil engineering skills" that are so necessary and expedient for the young engineer. Space in this publication will permit only to name such procedures: (1) Talks by practicing engineers, contractors, materials and equipment men and other professional men; (2) Inspection trips; (3) Seminars and conducted debates in recitation courses on text book topics; (4) By intensifying the questions put by the student and to extract the answer from the student as fully as possible; and (5) Through the traditional frequent written and oral tests combined with final examinations.

Each instructor has his own native traits for developing skills in his students, and fortunately so. This personal factor will help to broaden the viewpoint of the student of civil engineering theory and practice; this is sufficient cause for the teacher to "Find" and "Use" those inherent qualities peculiar to his own personality. The "professional attitude," "general understanding," and "skill" of the instructor appear to the writer to be a very important direct factor in effective teaching.

ENGINEERING ECONOMY PAGE

Engineering economy is that phase of engineering work in which technical plans and operations meet the critical and constructive tests of applied economics.

EDMUND D. AYRES, University of Wisconsin, *Editor*

LET US REACH AN AGREEMENT ON FUNCTIONAL OBJECTIVES

From the varying viewpoints as expressed in the definitions and discussions on "engineering economy," one would infer that the teachers of this important phase of engineering instruction are far from agreement on such vital questions as course objectives and course content. Professor Grant defines "engineering economy" as dealing with comparisons between technical alternatives in which the differences between alternatives are expressed as far as practicable in money terms. This definition may appear to some teachers as rather restrictive, but it has the virtue of excluding the many related and distantly related subjects which have little or no bearing on the fundamental principles involved in engineering economy problems. The definition gives this phase of engineering study a definite sphere of influence.

When we consider the ever increasing need of engineering economy studies in the practical pursuit of all branches of engineering, the subject assumes an importance which bids well to make it a desirable requirement in all engineering curricula. The writer has for several years taught a course in "engineering economy" which is a part of the required curriculum in civil engineering. Other departments, such as mechanical, electrical and mining have considered this course to be a very desirable elective, therefore it has been necessary to have a definite objective which would be equally valuable to these several branches of engineering. The course as taught deals with the "Will it pay?" aspects of engineering decisions.

The many related subjects which are often included under the title "engineering economy" largely serve the purpose of confusing the fundamental principles in the student's mind leaving him with only a superficial understanding. This criticism is often directed at the departments of general economics. Therefore, let us as engineering teachers reach some agreement as to the functional objectives to be obtained in our courses in "engineering economy" so that this same criticism cannot justly be laid at our door.

E. W. CARLTON,
Missouri School of Mines.

BOOK VALUE NOT REAL VALUE IN REPLACEMENT ECONOMY STUDIES

PROFESSOR DOOLEY CLEAR (in answer to WILL B. PRACTICAL'S query in the March issue):

I cannot help but feel that your difficulty is caused by your failure to appreciate that there is no necessary connection between book value and any

sort of real value. I am sure you will agree with me that in setting depreciation rates we aim to get the book value down to realizable value at the time the life of the equipment comes to an end. If we could set depreciation rates accurately there would never be any difference between book value and realizable value and the unamortized-value part of the replacement problem would not exist. If there is a difference between book value and realizable value it simply means that we have made an error in our depreciation charges and it seems to me only logical that we should handle the matter in such a way as to correct the error where it has occurred, or in other words that we should use the realizable value and pay no attention whatever to any incorrect book value.

In speaking of equipment which is located so far away from civilization that it has no re-sale value and where in addition the cost of removal is large and essential to replacement you state "Such equipment has value because of its performance and to say that that value is negative for purposes of comparison the day after it is erected because its second-hand value is nil and its salvage value is negative just does not make sense." I certainly cannot agree that the equipment to which you refer necessarily has any value whatever. If such equipment can be replaced with other equipment that will do the job more economically, such present equipment certainly has no value whatever no matter how much has been paid for the equipment nor what its physical condition may be nor how short its life may have been. It is very possible that the investment in this present equipment may have resulted in a very great and very real loss, but this loss is not reduced in any way either by our failure to recognize the loss nor our failure to replace the present machine with another machine which will be more economical. In fact in the latter case we are simply increasing our loss by continuing to use equipment which is not as economical as some other equipment might be.

You say that it is not fair to say that it is somebody's mistake if an unamortized loss occurs in such case. In my own rather extensive experience in industry I have never known of a case where a mistake of this sort was excused for the reason that it would not be fair to hold the offender responsible for his mistake. It has been my own experience that successful business men aim to write off mistakes of this sort as rapidly as possible and to forget about them completely except as they may use them to prevent a repetition of such mistakes in the future.

PAUL T. NORTON, JR.,
Virginia Polytechnic Institute.

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*, University of Virginia

IV

SPEECH TRAINING IN COLLEGES OF ENGINEERING *

By DONALD HAYWORTH

Head of the Department of Speech and Dramatics in Michigan State College

This chapter is a critique of seven hundred letters and questionnaires which the Committee on English received from students of engineering who have studied speech, graduates of engineering colleges, teachers of English and speech (including heads of departments), and administrative officers.

I

Student Opinion

Twelve representative institutions returned 335 questionnaires from students now in college who have taken speech. Although the speech courses in these institutions varied considerably in length, they followed, almost without exception, the generally recognized practices of teaching beginning public speaking: use of a modern, standard textbook; careful attention to outlining; utilization of the class hour almost wholly for speaking, but with criticism by the instructor and members of the class.

Since the first two questions of the questionnaire were asked for the purpose of evaluating the student's ability to give a judgment, we may begin with the answers to the third question.

Question 3: Would you favor changing the aim of the course?

Only eight of the 335 favored changes in the aim of the course. But when these eight suggestions are analyzed it is seen that they

* This study was prepared with the coöperation of the National Association of Teachers of Speech.

are really directed at methodology, rather than at the educational objective. Apparently every student believes that an engineer should be able to speak well in public.

Question 4: What suggestions have you for improving the method of instruction in speech?

In considering these suggestions the fact should be held constantly in mind that most students formulated no complaints. It may reasonably be assumed, however, that many of them would agree with the suggestions that were made. For convenience, the suggestions may be classified in the following categories:

a. Students should give more speeches. This specific comment was made by 43 students. In the institutions studied the number of speeches ranges from seven to seventeen. In many institutions there is an effort to get each student on his feet once a week. Apparently, however, this is not often achieved. The total number of speeches seems to average about ten for a course of eighteen weeks, meeting three times a week. Several students suggested shorter and more frequent speeches. In view of the answers to the questionnaires and the practices in the various institutions, it seems that in order to satisfy students the course of average length should have at least twelve or fifteen speeches.

b. Sections should be smaller. This was the protest of 38 students. It seems that sections run between twenty and thirty, except at two institutions where they are restricted to about fifteen. Only at these two institutions was there no complaint as to size of sections. At the same time, many students wanted the experience of speaking to larger groups. Recognizing that the two features are incompatible, they invariably prefer smaller sections.

c. The public speaking course should be longer. The courses studied ranged from one and one-third semester hours to six semester hours, the typical being three semester hours. There were fourteen students who wanted the course lengthened. Several students suggested that the amount of time allotted public speaking should be doubled, thus making it a year course of three hours each week.

d. Not enough individual criticism of speeches. This was a complaint of 32 individuals. In those answers in which a reason was given, the fact that sections were so large, or that the course was so short, was given as the reason.

Looking back over the four complaints listed above, one will see that they all arise from a *lack of sufficient instructional force.* When 105 students out of 304, all answering their questionnaires alone and in widely scattered institutions, think first of this one

complaint, it is apparent that their grievance should be recognized. Only the administrators can provide the answer.

Nevertheless, speech instructors cannot go entirely free. Students have some complaints on teaching procedures as well as some valuable suggestions.

e. Less emphasis should be given theory. This took many forms: "Too much outside reading"; "written work not practical"; "less emphasis in grading should be given to tests and written work"; "textbook not useful in the course"; "too much routine 'made' work"; "ought to have more work on delivery." Some seemed especially bitter about doing a great deal of what they believed was unproductive work. This complaint appeared in one form or another often enough for us to take it seriously. Students are apparently not convinced that outside reading, or that the written work, such as notebooks, is of any real value. One of two things must be true: either the assignments in question are unwise, or more attention should be given to motivation.

f. Discuss the text more. Only a few students were disappointed with their texts. There were many more complaints that the text was not discussed enough and was not related to the classwork. Undoubtedly, this is a significant point and may partly explain the preceding criticism. Those of us who teach in the field know how easy it is to assume that the reading of the text is something that can be done without guidance; or we can become so much interested in the day's speeches that we ignore the reading we have asked our students to do. The study of theory may thus become divorced in the student's mind from speaking practice and seem to be mere "busy work."

g. Use a recording device. Where voices are systematically recorded, students greatly appreciate it, and in those institutions in which this has not been done there is an occasional student who sees voice recording as the great need in the course.

h. Provide more opportunity for private conferences. Eight students felt unable to solve their problems in a class. They wanted private conferences with the instructor. No information is available as to the amount of conference work now being done.

i. Impromptu speaking should be increased. Thirteen students would like to have more impromptu speaking. They feel that prepared speeches are desirable, but that much of an engineer's speaking will be without preparation for the occasion.

j. The questionnaires also elicited a miscellany of suggestions which occurred two or three times each. Some are pertinent, as for example: exchange students between sections in order to give an unfamiliar audience; more emphasis on reducing stage fright; more instruction in conversational speaking as opposed to public

speaking; give practice in conducting an open forum; assign more technical speeches. Others merely reflect general attitudes, such as: too much work; insist on better speeches; not enough persuasive speaking; too advanced. Two students suggest that moving pictures be taken of students while speaking, and one urges that instructors do less "lecturing" but instead give short speeches to the class occasionally to demonstrate good technique.

Question 5: Do you believe speech should be required in engineering colleges?

Affirmative answers totalled 241, 9 were undecided, and 16 were in the negative. Answers were frequently made most emphatic with such phrases as "Most emphatically, YES"; "Absolutely!"; "Yes, we all need help." Of the negative answers, seven were from one institution which furnished 23 questionnaires. But even in this institution the negative answers were usually qualified by the statement that speech should be an elective. The most casual survey of the opinions of these students reveals the unquestionable enthusiasm of students for the work.

Question 6: Compared with other non-engineering subjects in the curriculum, how would you rate the value to you of *your* course in speech?

One of the least valuable	16
Slightly under average value	16
average value	40
Slightly above average value	68
One of the most valuable	137

Since these answers were made by check marks, an examination of the questionnaires as filled out reveals nothing beyond the figures.

Question 7: In what year in college would you have it placed?

(Note: The figures in the first column represent the answer to this question. The figures in the second column show when the students themselves took the course.)

Freshman	91	76
Sophomore	109	120
Junior	71	65
Senior	39	54

It is rather surprising to observe how closely the two columns correlate. Examination of the questionnaires reveals that students tend to believe that the year in which they took the course is the best year.

Question 8: Did your course in speech have any effect on your writing ability?

Question 9: Did your course in composition have any effect on your speaking ability?

These questions may well be dealt with together. The statistical results of the questions are:

	Yes	Perhaps	No
Effect of instruction in speech on writing	132	33	106
Effect of instruction in composition on speaking.	173	25	64

Apparently this tends to show that instruction in composition has a greater effect on speaking ability than has speech instruction on the ability to write. But since a large proportion of the answers indicated that speech was taken after the course in composition, it is difficult to know what the relation would have been if the order had been reversed.

The item most frequently mentioned was in respect to organization. Fifty-six stated that their work in English had made speech outlining easier. Conversely, 50 found that instruction in speech made it easier for them to outline a subject to be developed in writing. A great many found the courses to be mutually helpful in this regard.

It was believed by fifteen that lucidity of oral expression was increased by instruction in writing, while eighteen found that there was a transfer of ability in lucid expression from the speech course to writing ability. There were 36 who stated that writing so expanded their vocabularies that it increased their effectiveness in public speaking. Exactly one-third of that number were of the opinion that a speech course enlarged their writing vocabularies. The course in English composition was given credit by 27 for improving their grammar and thus preparing them for better public speaking. Only one found that the public speaking course improved his grammar.

Speech instruction, in the opinion of 23, increased their ability to write by making them more aware of the reader. Previously they had not written with the reader in mind, but after taking speech they realized that the purpose of language, written or oral, is to achieve significance for the listener or reader as the case may be.

Quite frequently individuals stated most emphatically that there was no relationship between composition and speaking; while others just as emphatically claimed that the essential natures of the two were one and the same.

II

Opinions of Graduates

The committee's letter of inquiry was intended to evoke general comment, and the answers give a number of definite impressions. It was assumed by all of the 153 who replied that public speaking should be taught. Fifty-six volunteered the belief that it should be compulsory, and the other letters quite generally made the assumption. Only one suggested that it be an elective. Many said it should be extended, while no one believed it was over-emphasized.

It is very apparent that graduates look upon speech as public speaking, *i.e.,* a so-called practical course. Quite frequently they declare that they believe in the study of literature for its cultural value, but no one assumes that speech is or could be cultural. Speech instruction is apparently identified by many graduates with the techniques and aims of Dale Carnegie. The more nearly it fits that pattern the more it is appreciated. The only exception, and fundamentally this is no exception, was the occasional statement that conversational speaking (including the interview) should be taught—because it is so *practical.*

Only one stated that English composition and speech should be taught together; in the main, the customary division of these two into separate courses under instructors with specialized training was accepted as more efficient. Other suggestions mentioned once or twice were:

Instructors in speech should have a background of business.
Most public speaking instruction in colleges is not practical.
Public speaking teachers emphasize delivery to the exclusion of subject matter.
Public speaking should be taught by men.
Extra-curricular activities should be encouraged.
Correction of speech defects should be provided.

A reading of the letters leaves the distinct impression that graduates of engineering colleges would like to see more instruction in public speaking, and that, in the main, they are sympathetic with the type of instruction now offered. It is very apparent that older graduates are less satisfied than are those of more recent years, a fact explained, no doubt, by the shift in speech instruction from the older "elocution" to the modern emphasis on "practical" speech-making.

III

Opinions of Instructors

Sixty-seven instructors of speech in engineering colleges answered requests for their opinions on five questions, as follows:

Question 1: What type of speech training, in your opinion, should be taught in engineering colleges? Please include in your answer comments on educational objectives, skills, knowledge, appreciation, etc.

Answers showed overwhelmingly the opinion that training in public speaking is considered preferable to any other type of instruction in the field of speech. General effectiveness in conversational speaking was mentioned by nine instructors. "Fundamentals of speech" (a rather loose, general term, which is familiar to speech teachers as embracing such things as articulation, vocal quality, and pronunciation) was mentioned by only four. There was a scattering of such objectives as vocabulary building, parliamentary procedure, socialization of the personality, development of self-confidence, voice training, phonetics, anatomy of the organs used in speech, interviewing, and cultural development.

Question 2: How many term or semester hours do you think are needed to accomplish the above objectives?

Let us state this in the total number of hours of recitation, taking a term as twelve weeks, and a semester as eighteen weeks. Answers ranged from 36 (one term of three hours) to 162 (three semesters of three hours). It must be remembered that this range is due in great measure to differences in educational objectives. The instructor who asked for only 36 hours proposed to give no more than a brief introduction to a few kinds of public speaking situations. The instructor who asked for 162 hours proposed to overhaul with great thoroughness the whole personality as it is revealed in speech. Undoubtedly, too, the difference in sizes of sections was an important factor. In one institution instructors deal with groups of four to seven; elsewhere, undoubtedly, the assumption is that classes would consist of twenty-five or thirty.

The average length of course suggested by instructors was about 80 hours, which is equivalent to one semester of four hours, or a little more than two terms of two hours. Since most institutions operate on a semester plan, replies were usually expressed in semesters. The three most popular suggestions, ranking almost equally, were:

One semester of three hours (54 meetings).
Two semesters of two hours each semester (72 meetings).
Two semesters of three hours each semester (108 meetings).

We must point out that two opposing influences tended to operate in the minds of those who answered this question. First, they realized, as was so often stated, the fact that the engineering curriculum is extremely crowded; and second, they are speech teachers with a natural prejudice in favor of their own discipline.

Question 3: Please describe your course now being offered engineering students.

The answers showed almost the same results as were shown in the answers to the first question, namely, that the typical instruction in *public speaking,* as so widely taught throughout the entire country, is being offered students of engineering. Such a finding would certainly not obtain in a survey of liberal arts colleges or teacher training institutions, for in both of those one would find much more instruction in "fundamentals."

Question 4: Do you know of any way in which your administration could help you make your work more effective than it is now?

This question brought only a few, scattered answers. Nearly all instructors of speech are apparently well satisfied with the cooperation of the administrators, and many are exceedingly vigorous in their appreciation. Below are listed the few scattered suggestions made by 67 instructors, with the frequency of reference in parentheses.

Make provision for more instructors and thereby smaller sections. (9)
Courses should be lengthened. (4)
Speech should be required. (2)
Buy sound recording equipment. (2)
Advisers should be more sympathetic to speech. (2)
Allow more election in advanced classes. (1)
Other instructors should require better speech in recitation. (1)

Question 5: In what way is the engineering faculty facilitating or using the work you are doing? What additional assistance or cooperation would be desired?

The head of one department emphasized the value of the moral support made evident through the offering by engineering faculty members and alumni of prizes for speech contests among engineering students. Frequent invitations to discuss the presentation of technical reports in engineering seminars and the preparation by instructors of engineering of technical bibliographies for use by speech students in the preparation of technical speeches were cited as evidences of cordial coöperation. Although no other mention was made of it, similar coöperation no doubt exists elsewhere. There seems to be scarcely any coördination of speech instruction with class work in engineering, however, and apparently no need of such coördination is felt.

IV

Opinions of Deans and Presidents

Letters were received from administrative officers of some seventy institutions. In nearly half of the institutions public speaking is offered, and in most of these it is required. Administrators of two institutions showed dissatisfaction with the work being done in public speaking. The great majority showed enthusiastic approval of the work done. No administrator advocated any decrease in speech, and a number advocated an extension of the work in this field.

In eighteen of these institutions there is no attempt to teach speech in any form and no pretense that it is taught. In twenty-two institutions the administrative officer says that there is a course in English, oral and written. Probably many of these institutions have courses in freshman English composition but actually no speech at all. Many college catalogues contain a statement to the effect that the freshman English course is devoted to "oral and written" composition, but the actual instruction minimizes the former; the speech instruction consists of a few "oral themes" or the informal discussion of selected topics rather than training in the sort of practical speech-making apparently desired by students and graduates. This is, of course, readily understandable when we realize that no English department has ever given graduate work to prepare teachers to coördinate the two. Even if administrators wish to have both composition and public speaking taught in the same course, they can not find teachers trained to do the work.

In view of the apparent general satisfaction with speech training in institutions where it is offered, the absence of any speech instruction at all or the limited amount of it in more than a third of the engineering institutions reporting may well be questioned.

V

Conclusions

1. There is general approval of the present aims and practices in the teaching of public speaking.
2. There is no appreciable or general dissatisfaction with the instructors of public speaking.
3. Sections should be smaller—even though this takes more money. Probably English and speech are much more cheaply taught per credit hour than most engineering subjects, and large sections in public speaking not only thin the educational content, but waste the student's time. (One thing not

often noted by administrators is that a public speaking instructor generally has "outside activities" to supervise—debates, plays, etc. If he carries this work in addition to a full teaching schedule he is likely to be overloaded. Without such duties it is usually fair to ask him to carry a slightly higher number of class hours than most instructors in other subjects.)

4. Public speaking should be required of engineering students. The composite opinion of students was that it should come about the sophomore year. However, it is the opinion of the author that it should be given in the freshman year—largely because of the belief that any changes in linguistic habits should come as early as possible. One graduate stated that a student should not be allowed to speak in public until he at least *knows* how to speak properly. But this may be just as reasonably be reversed. Speech processes normally precede writing in childhood. How can anyone write with skill until he can speak the language with reasonable confidence?
5. Students, instructors, and graduates come into general agreement in suggesting a longer course in public speaking—perhaps a minimum of four hours for one semester with sections of eighteen. The amount of credit might be reduced to three. Instructors in public speaking would probably agree that classes should meet at least three times a week rather than less frequently over a longer period. One of the great weaknesses of the present "oral and written" combination is the attempt of many English instructors (not trained in or sympathetic with speech) to have "oral work" once a week. For at least half a dozen reasons such activity is a profitless waste of the student's time.
6. Little consideration has been given by anyone to the possibility of utilizing speech training as an instrument of cultural development. Probably this should not be done until more time has been found for the "practical" course.

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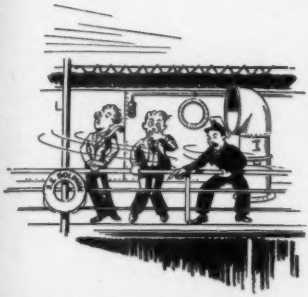

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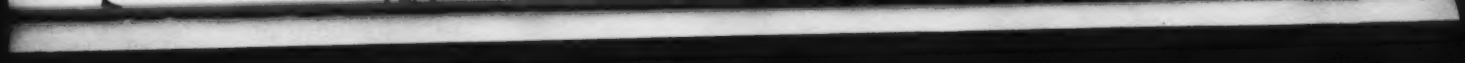

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